Monitoring for Saving

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Use of Labs 21 tools and monitoring systems in exploring energy savings opportunities in laboratories, a case study

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FEMP

LABS FOR THE 21ST CENTURY

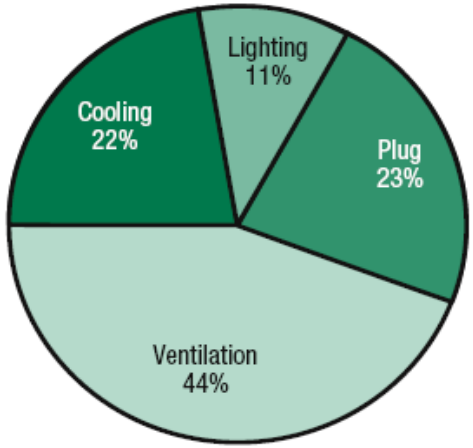
I²SL International Institute for Sustainable Laboratories

BERKELEY LAB

Goal: Energy-Efficient Laboratory

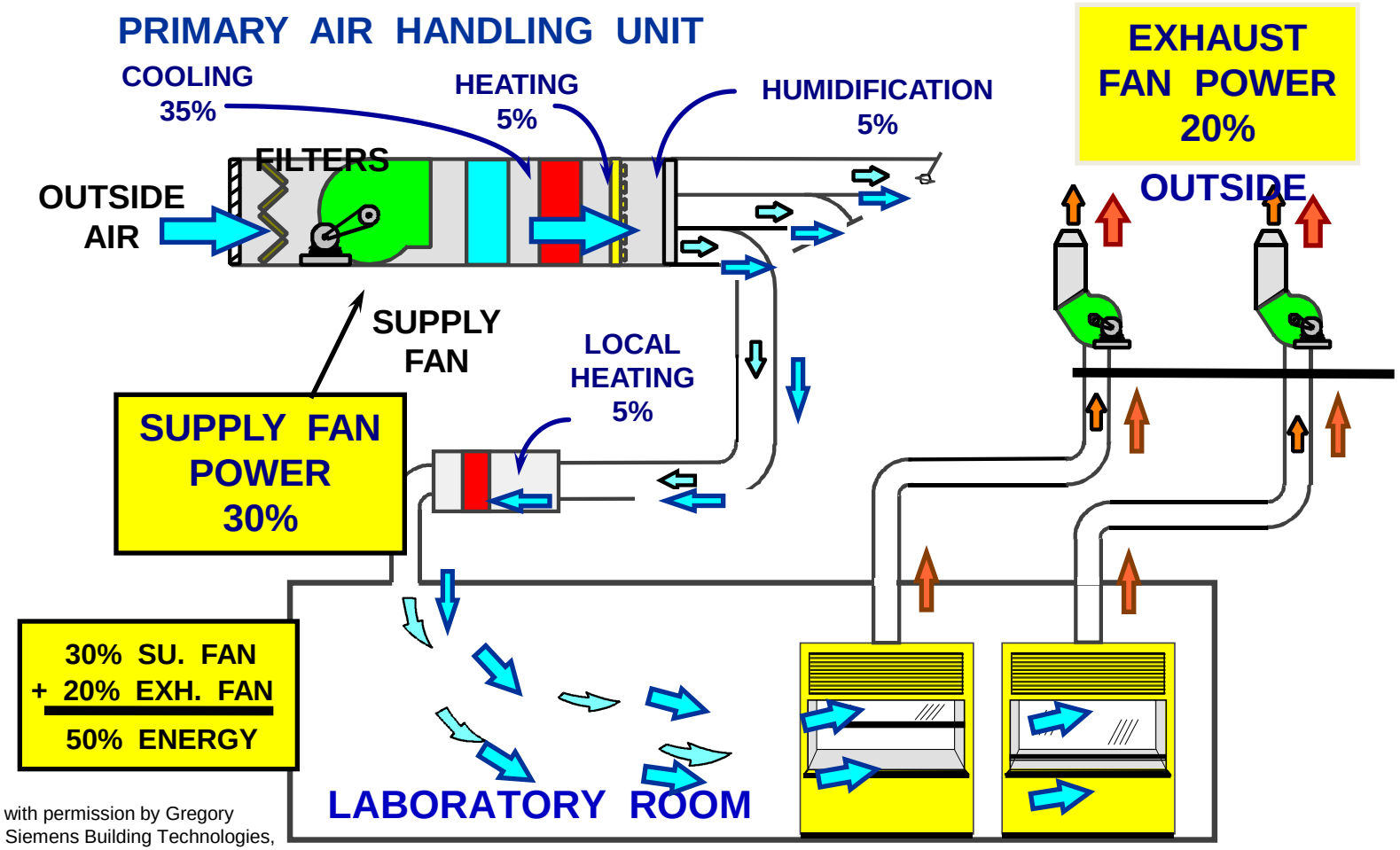
Objectives: At the end of this session, after a brief review of laboratory ventilation and HVAC basics you :

1. **Become familiar with the benefits of use of benchmarking and LEEP tools in discovering energy end use**
2. **Become familiar with benefits of the laboratory central monitoring and control systems**
3. **Discovering EEMs in a case study**
   1. **Optimize Ventilation (air change) Rates**
      - **Lower HVAC Fan-Energy Use**
      - **Lower cooling and heating with make up air reduction**
   2. **Minimize Simultaneous Heating and Cooling**



Annual electricity use in Louis Stokes Laboratory, National Institutes of Health , Bethesda, MD

Basic Lab HVAC System



Adapted with permission by Gregory DeLuga, Siemens Building Technologies, Inc.

Optimize Ventilation (AC) Rates

What is the Minimum, Safe Air Ventilation Rate?

- Few codes but many standards
  - Ventilation standards often expressed as a range (e.g. 4 to 12 air changes)
- According to IBC building codes:
  - IBC B occupancy requires ventilation based on people
  - IBC H-5 occupancy requires 1 cfm/sf of outside air.
- 1 cfm/sf translates to 6 air changes per hour (ACH) with a 10 foot ceiling.

Optimize Ventilation Rate

Strategy 1: Apply occupied versus unoccupied ventilation rates.

- Automate setback with control strategies.
- Zone proximity sensors
- Can be simple interlock with light switch.
- Sash stop

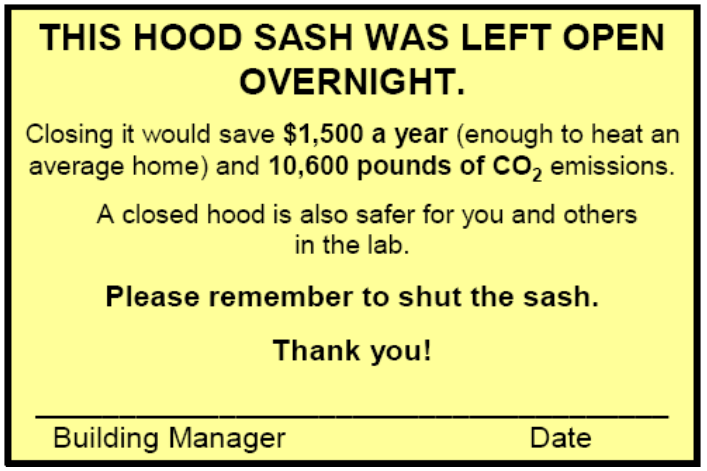
Strategy 2: Apply VAV exhaust and supply.

Recognize User Influence

- Users have great influence on **both** safety and energy efficiency.
- For example, VAV exhaust systems are useless when operators do not use it as intended; **close sash** when not in use.
- Comprehensive and reoccurring **training** is required.

Sash management

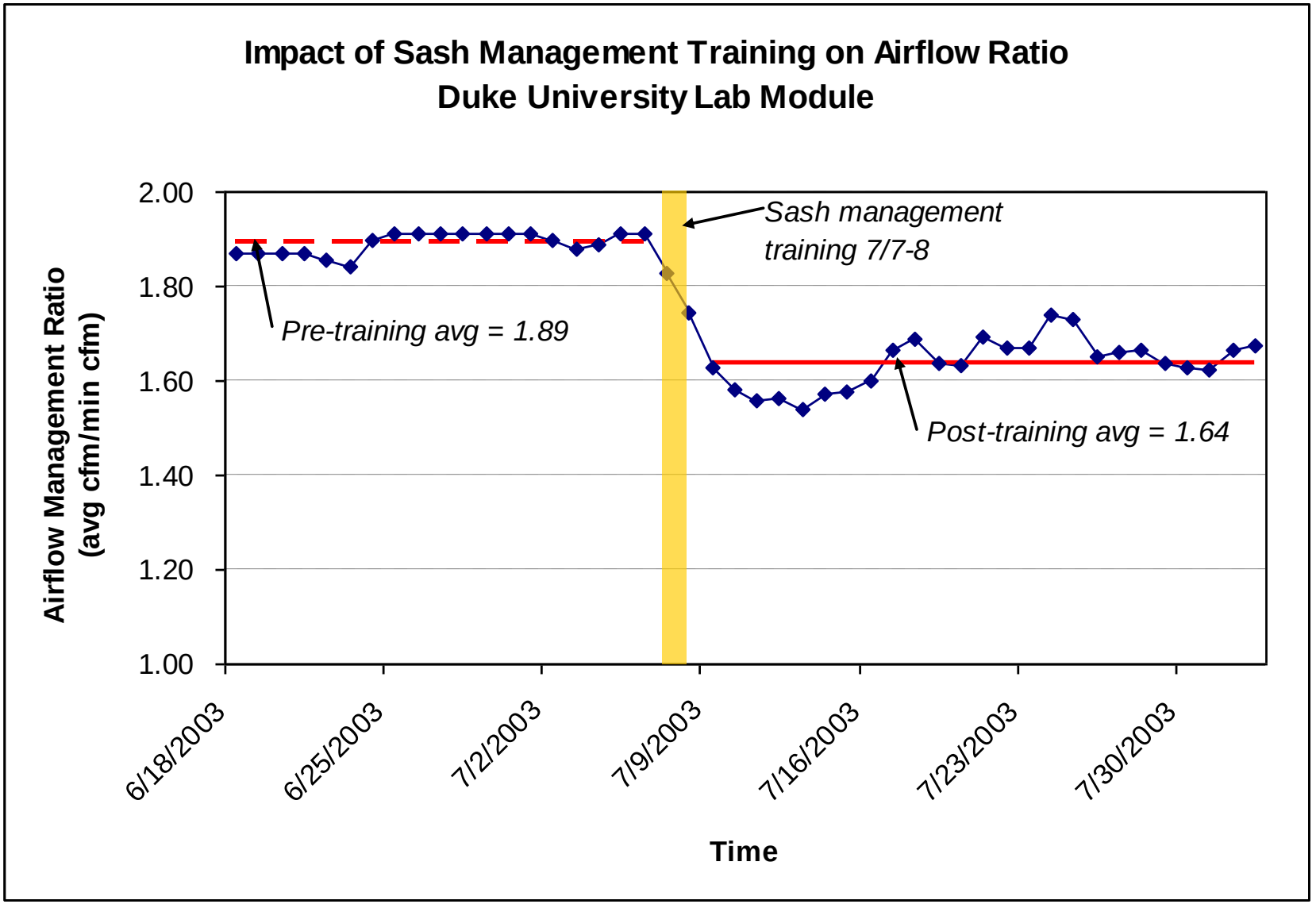
- Training and education
- Feedback to users
  - The stick
  - The carrot
- Automated sash management
  - Occupied and unoccupied set points (reset velocity set point)
  - Auto sash closure system
- Continuous improvement
  - Follow up regularly



Courtesy of *Harvard Green Campus Initiative*

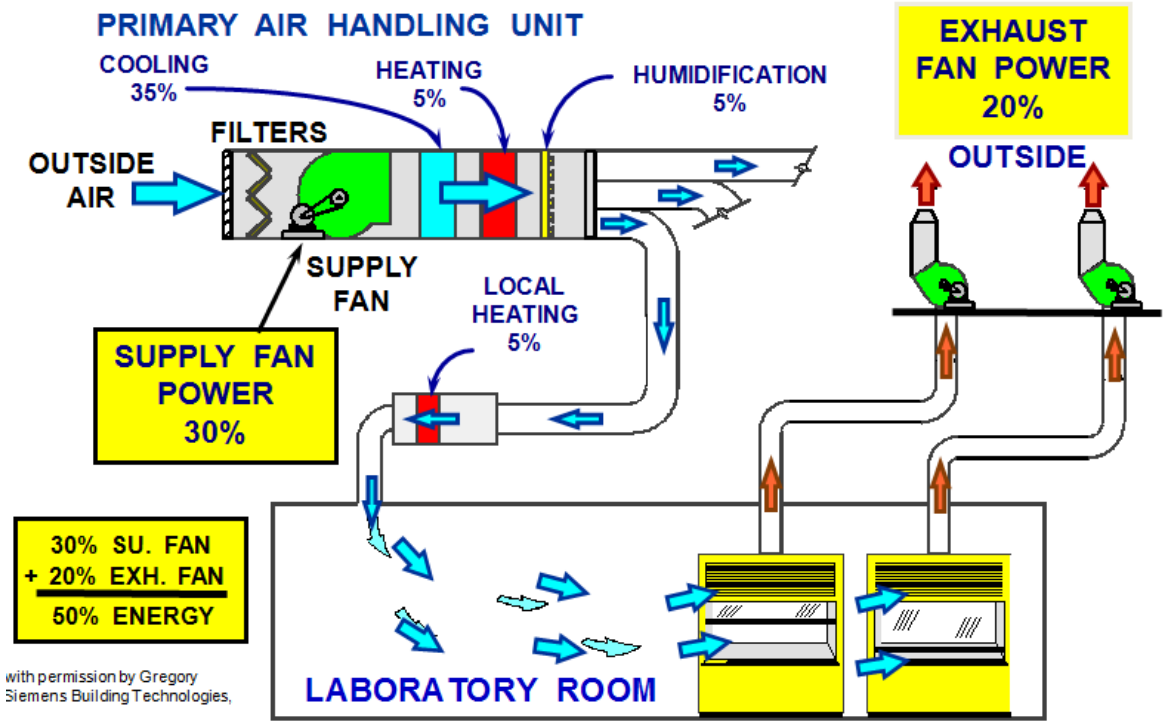
Courtesy of *Allen Doyle, UC Davis*

Impact of Sash Management Training



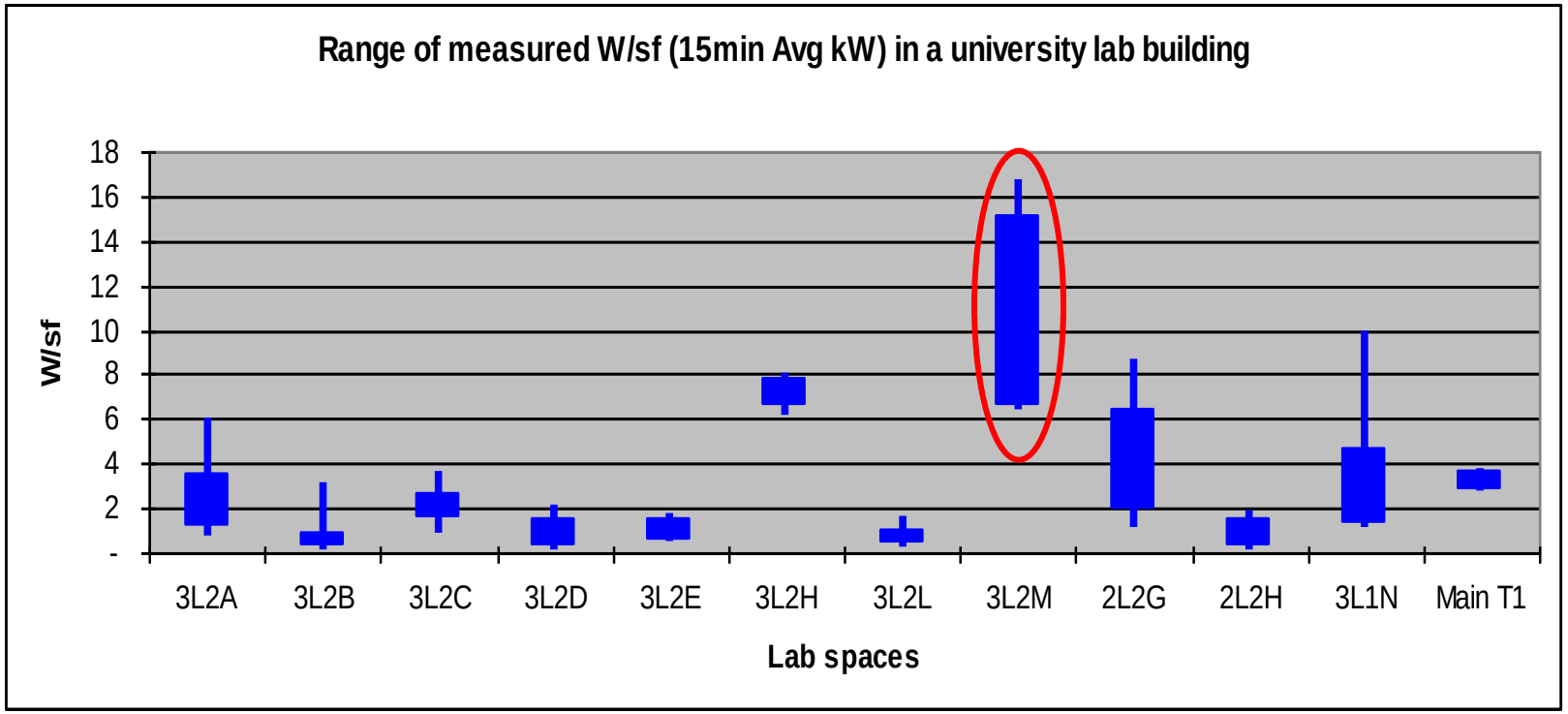
What is Simultaneous Heating and Cooling?

- Consider *only one* of many labs having a large, unanticipated, heat-generating load.
- HVAC system will provide cooler air to satisfy this higher-intensity lab.
- Consequently, all other lab spaces must be *re-heated*, after airflow has been expensively cooled.



Reheat (simultaneous heating and cooling) causes major energy waste in labs

- A single high load lab zone requiring cooling can artificially create reheating loads throughout remainder of laboratory…



Courtesy of UC Davis

System Alternatives to Minimize Reheat

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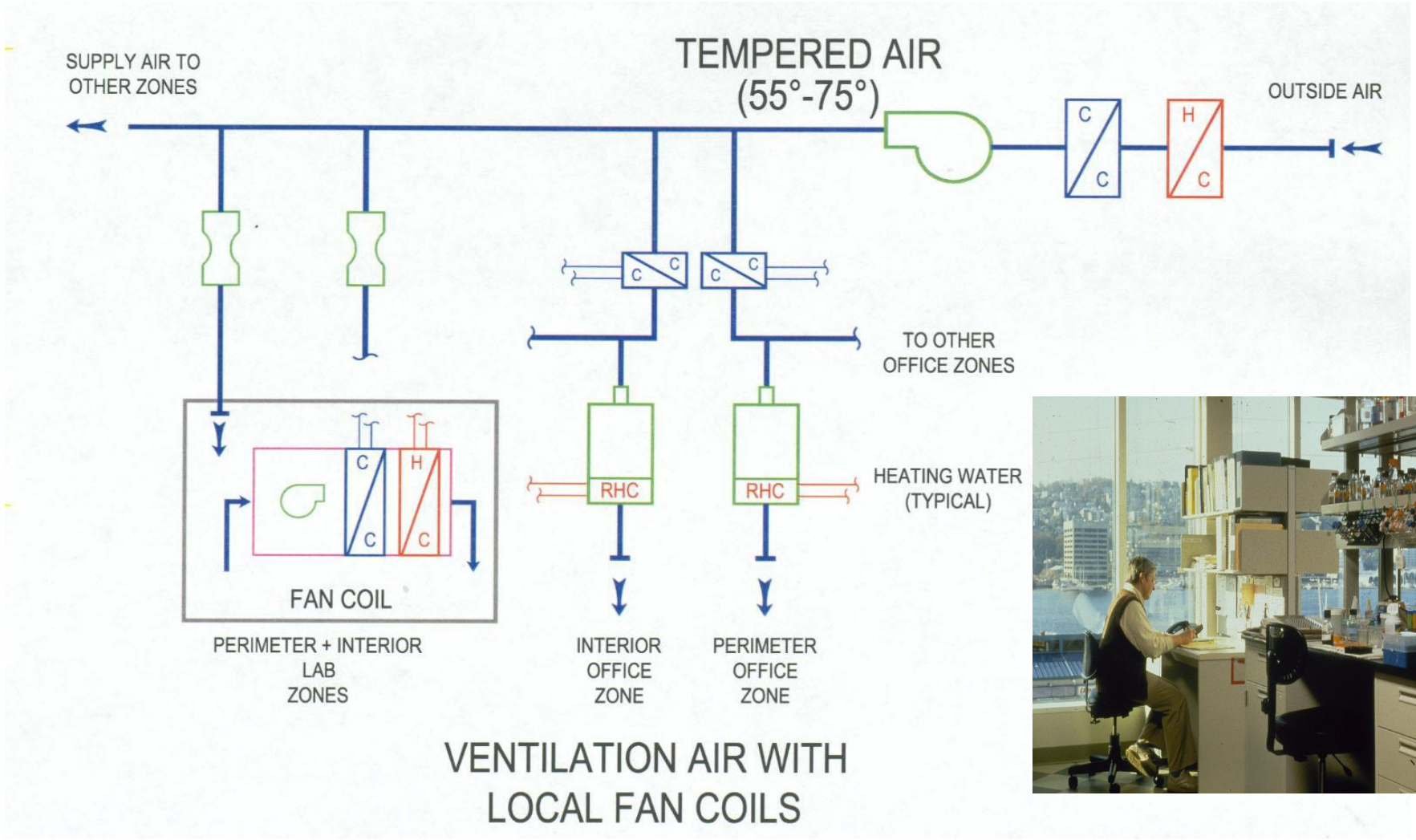
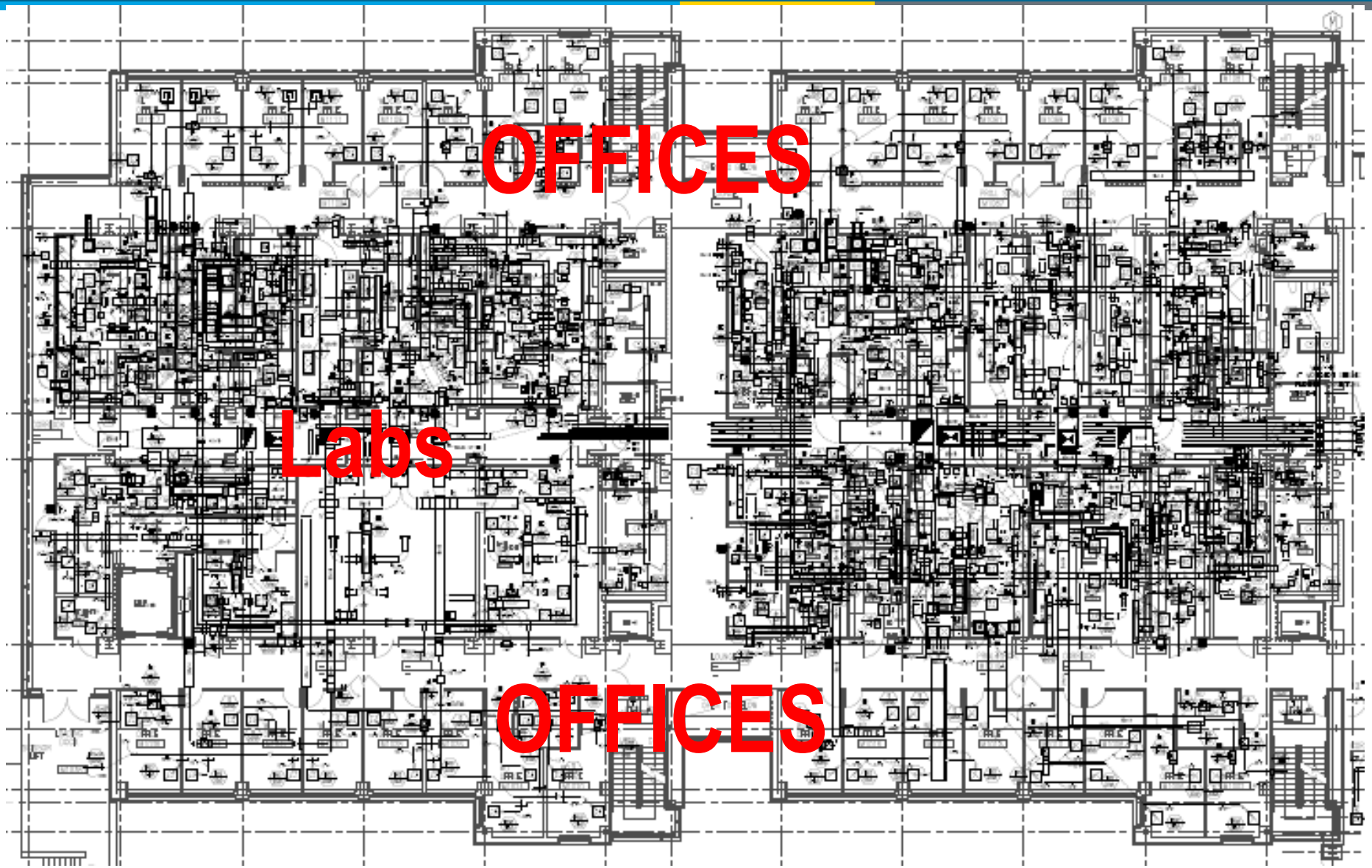
Separate ventilation from cooling to minimize reheat…



Case study - B15



Hoods in B15, efficiency opportunities

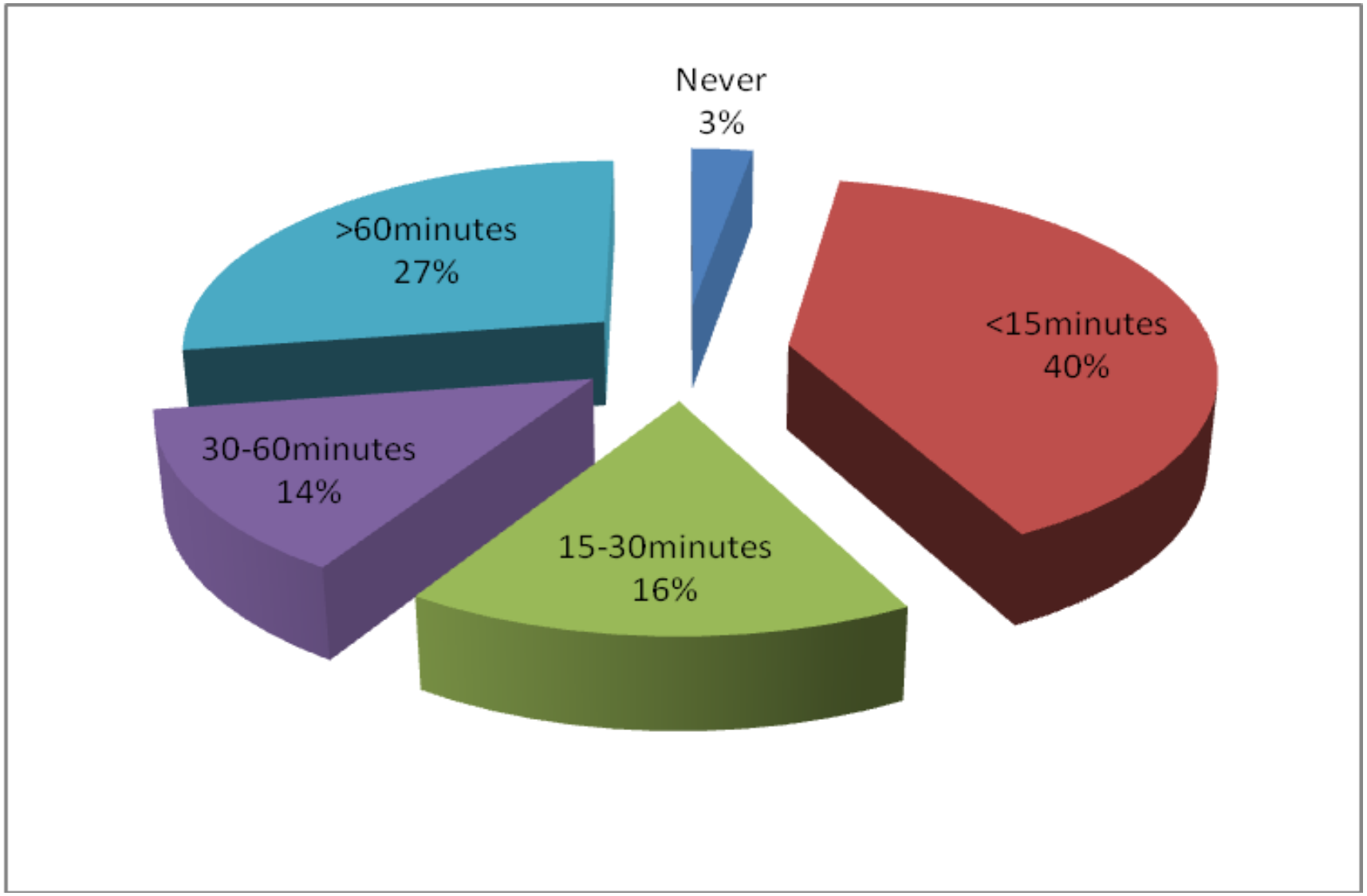
canopy hoods, seldom used

Open sash hood

No sash

Courtesy of ETC

Percent of fume hood use in B15, minutes per day



LABS 21 Benchmarking Tool

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LABS 21 Benchmarking Tool

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General Facility Data

User	rmahdavi
Organization	LBNL
Facility Name	
Year (for which this data applies)	2012

Street Address*	
Location*	
Zip Code (5 digit)*	
Organization Type *	Other
Lab Use (most prevalent)*	Research/Development
Lab Type (most prevalent)*	Chemical
Number of Buildings*	1
Gross Area (sq. ft.)*	200000

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Whole Building Energy Use Data

(The Energy use and cost data entered in this section should include ALL energy used by the building, including district steam / hot water / chilled water if applicable.
Enter 0 if not applicable)

More Information

		Measured	Estimated
Annual Electric Use (kWh)*	4200000	●	○
Peak Electric Demand (kW)	800	○	●
Annual Natural Gas Use (Million BTU)*	35000	○	●
Annual Fuel Oil Use (Million BTU)*	0	○	●
Annual Other Fuel Use* (Million BTU)	0	○	●
Annual District Chilled Water Use* (Million BTU)	0	○	●
Annual District Hot Water Use* (Million BTU)	0	○	●
Annual District Steam Use* (Million BTU)	0	○	●
Annual Energy Utility Cost ($)	690000	○	●

Ventilation System Energy Use Data

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benchmarking

step one of four - login

step two of four - enter facility name and year of data

step three of four - enter data for the facility

step four of four - review / edit entered data

General Facility Data

User	**rmahdavi**
Organization	**LBNL**
Facility Name	**USGS**
Year (for which this data applies)	**2012**
Street Address	345 middlefield rd
Location	Menlo Park, ca
Zip Code	94025
Organization Type	Other
Lab Use (most prevalent)	ResearchDevelopment
Lab Type (most prevalent)	Chemical
Number of Buildings	1
Gross Area (sf)	200000
Lab Area (sf)	40000
% Biological	10
% Chemical	80
% Physical	10
% Other	0
Vivarium Area (sf)	0
Number of Fumehoods	100
Total linear feet of Fumehoods	360
Total occupancy hours per week	60
Total Number of Occupants	180
Year Built (or major reNovations)	1996
Is this an existing building?	Yes - Existing Building

Lab Indoor Design Conditions

Occupied Cooling Setpoint (F)	72
Occupied Heating Setpoint (F)	72
UNoccupied Cooling Setpoint (F)	70
UNoccupied Heating Setpoint (F)	68
Humidity Minimum (%RH)	20
Humidity Maximum (%RH)	80

High Performance Features

HVAC	
VAV Fumehoods -	VFD for Fans/Motors - **yes**
High Efficiency Chiller Plant -	High Efficiency Heating Plant -
Thermal Energy Storage -	Automated Control Systems -
Energy Recovery -	Low Pressure Air Distribution -
No reheat -	Others -
Lighting	
Day Lighting Systems -	High Efficiency Lamps/Fixtures -
Automated Controls -	Others -
Envelope	
High Performance Glass -	External Shading Devices -
Others -	
Others	
Facility uses CHP (Cogen) system	Others -
Additional Comments	

Edit Data For This Facility

Benchmarking Analysis

Enter Data For Another Facility

Log out

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Others -	
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Edit Data For This Facility
Benchmarking Analysis
Enter Data For Another Facility
Log out

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Choose Metrics and Filtering Criteria

More Information

User rmahdavi
Organization LBNL

Select metric:

System: Cooling
Energy / Efficiency Metric: kWh/gsf-yr

Specify data filtering criteria:

1. Lab Area / Gross Area ratio
   is greater than or equal to 0.00 and is less than or equal to 1.00
2. Occupancy hours per week
   - Standard (≤80 hours)
   - High (>80 hours)
   - Both (all data)

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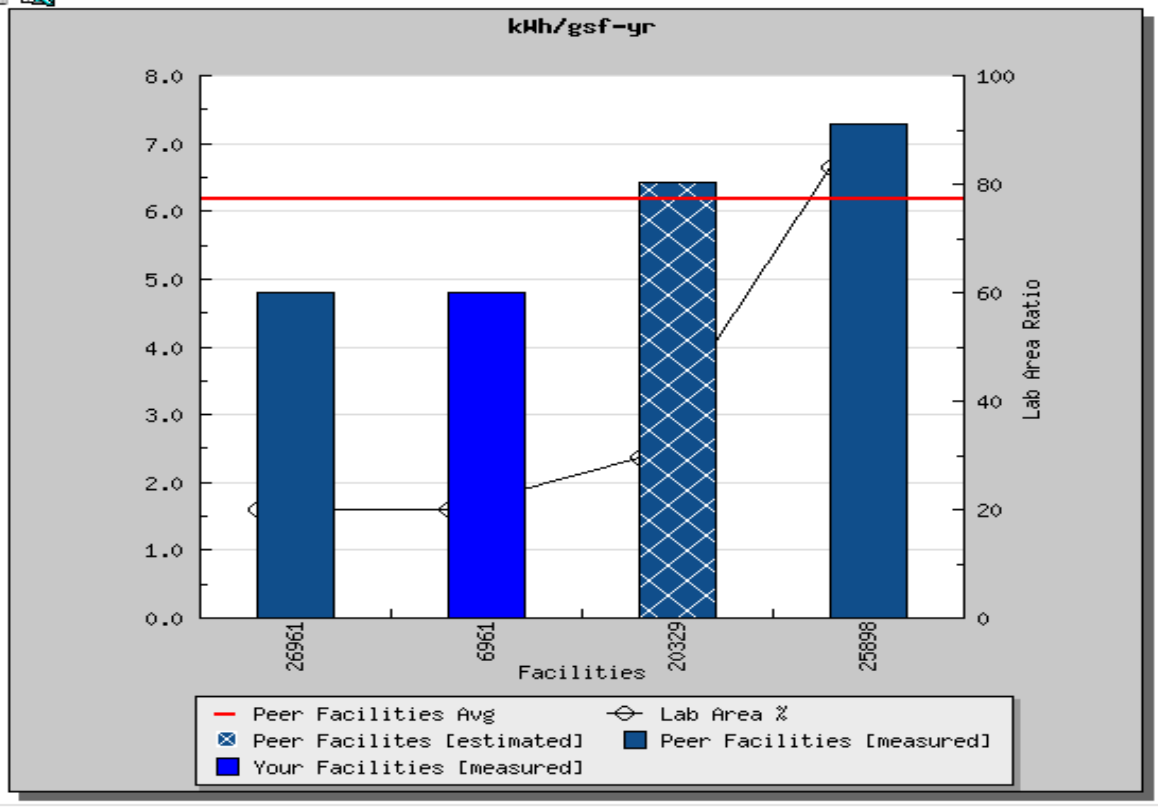

Lab area ratio: 0.00-1.00 | Occupancy hours: Both
Lab type: Chemical, Biological, Physical
Lab uses: Research/Development
Climate Zones: 3C
Measured data: Yes Estimated data: Yes

Benchmark Statistics for Peer Facilities

Metric	Min	Avg	Max	Count
Cooling kWh/gsf-yr	4.8	6.18	7.3	3

Click titles of columns below to sort
Data for your facilities are highlighted | Estimated data are indicated in *italics*

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Case Study Results

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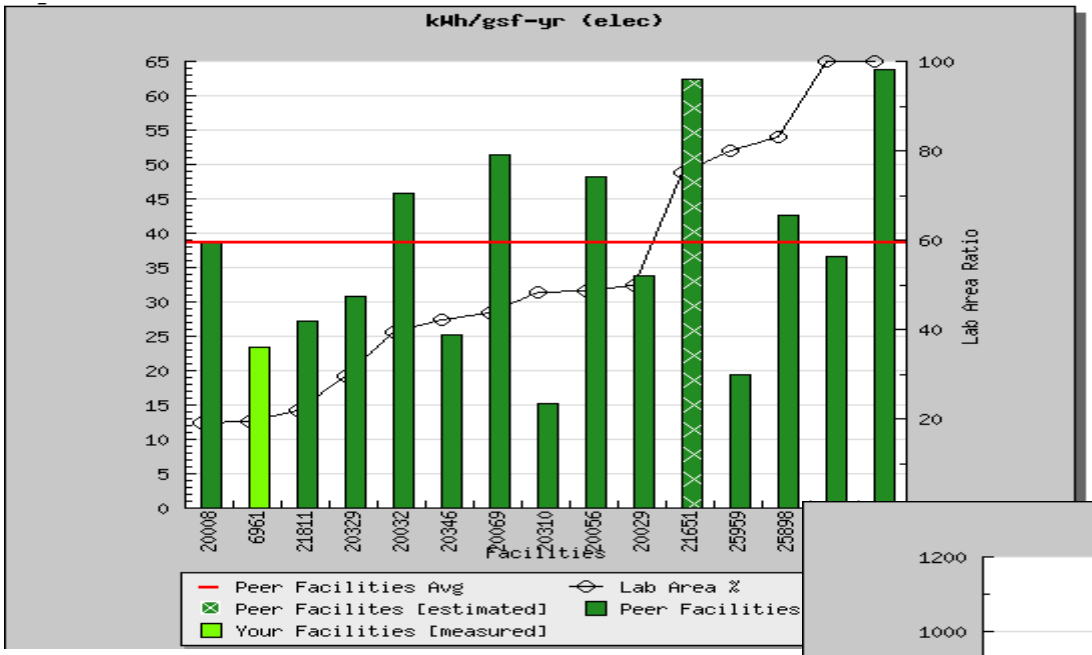

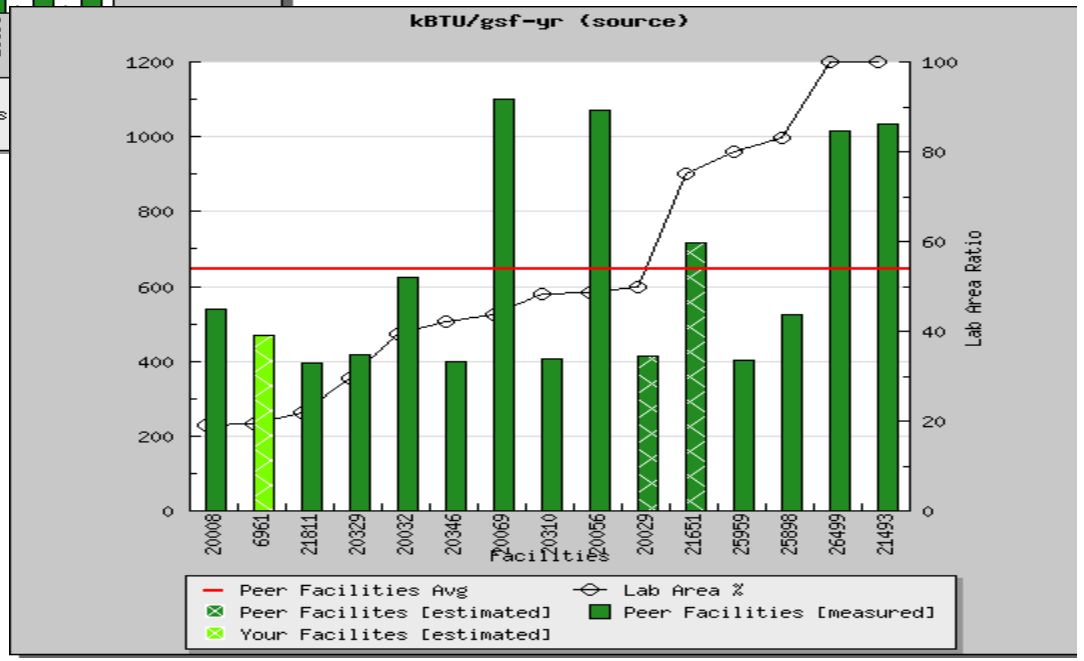

Lab Energy Efficiency Profiling Tool

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LABORATORY ENERGY EFFICIENCY PROFILER

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IDENTIFY POTENTIAL ENERGY EFFICIENCY OPPORTUNITIES IN YOUR LABORATORY

LABORATORY ENERGY EFFICIENCY PROFILER (LEEP)

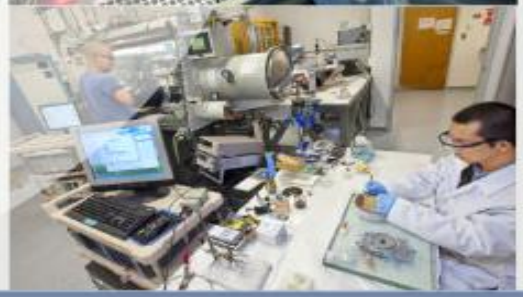
helps users to quickly identify and prioritize potential energy efficiency actions in laboratory facilities. It does not require users to have any specialized knowledge of energy audits or analysis. The tool inputs are the key characteristics of the facility's ventilation, heating, cooling and lighting systems as well as plug and process equipment. Based on these inputs, the tool provides information on the relevance, impact, and comparative cost of over 60 actions to reduce energy use. These results can then be used to help establish the scope and priorities for more detailed energy audits.

Username

Password

Login

Request A User Account



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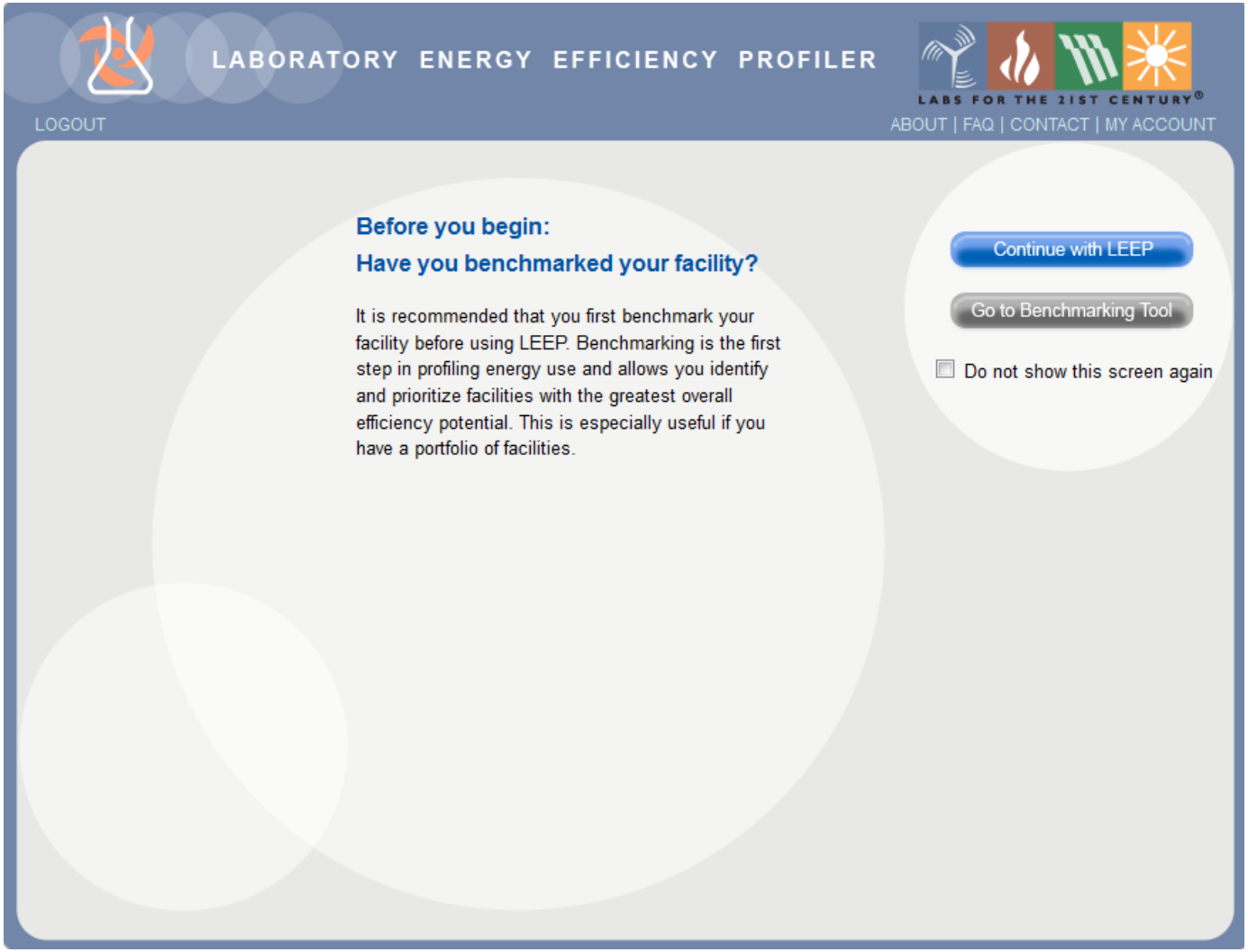

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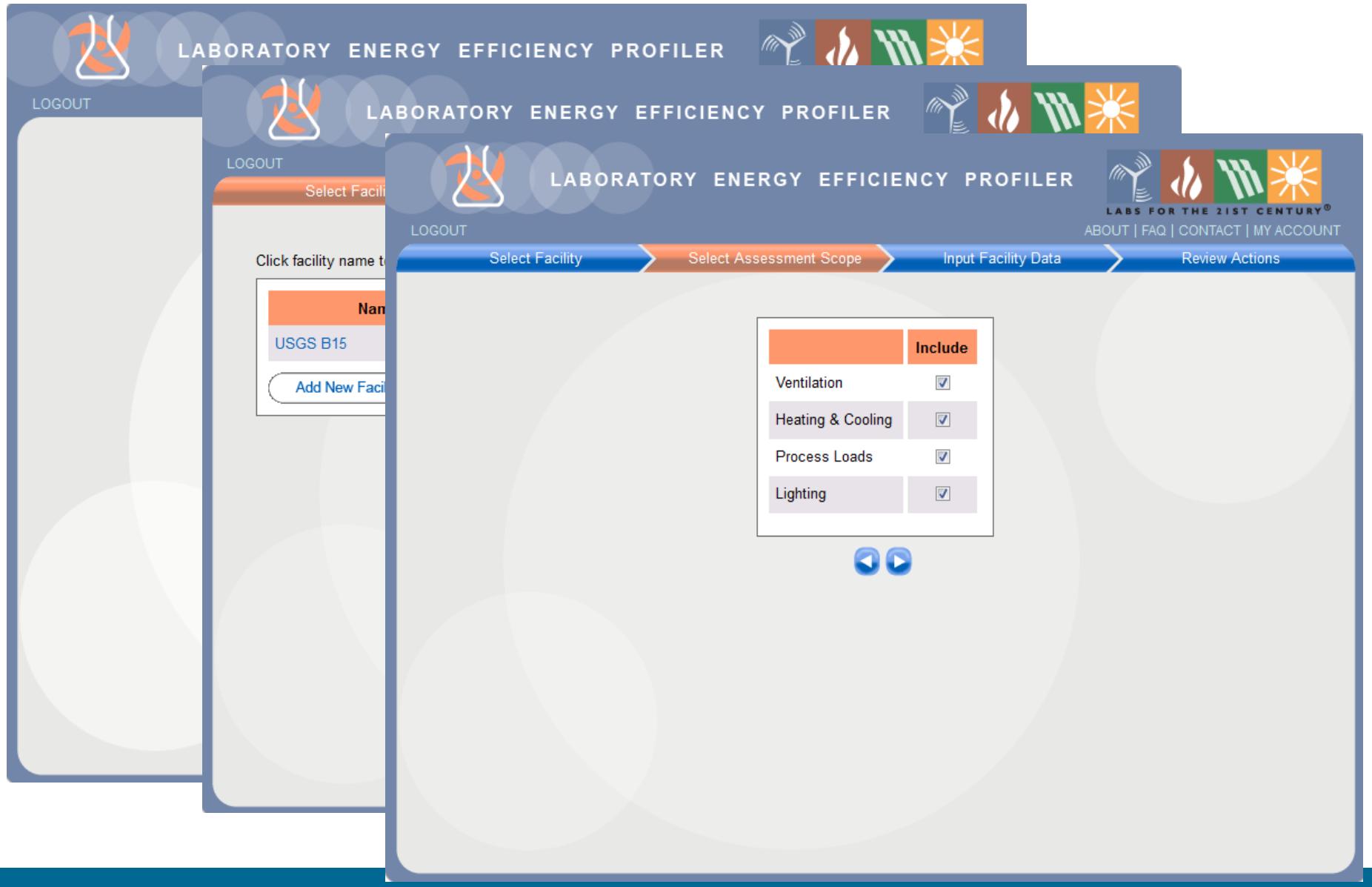

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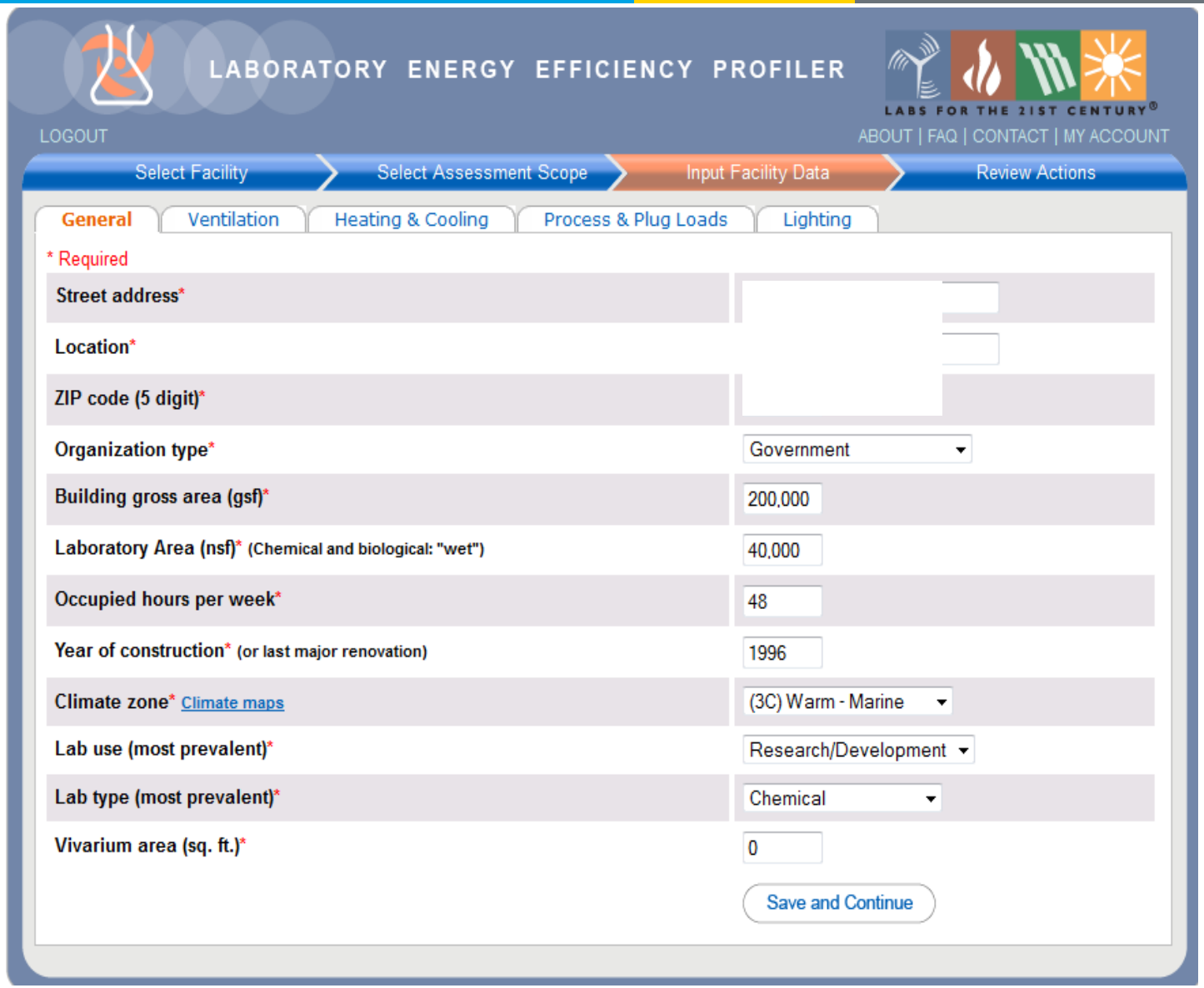

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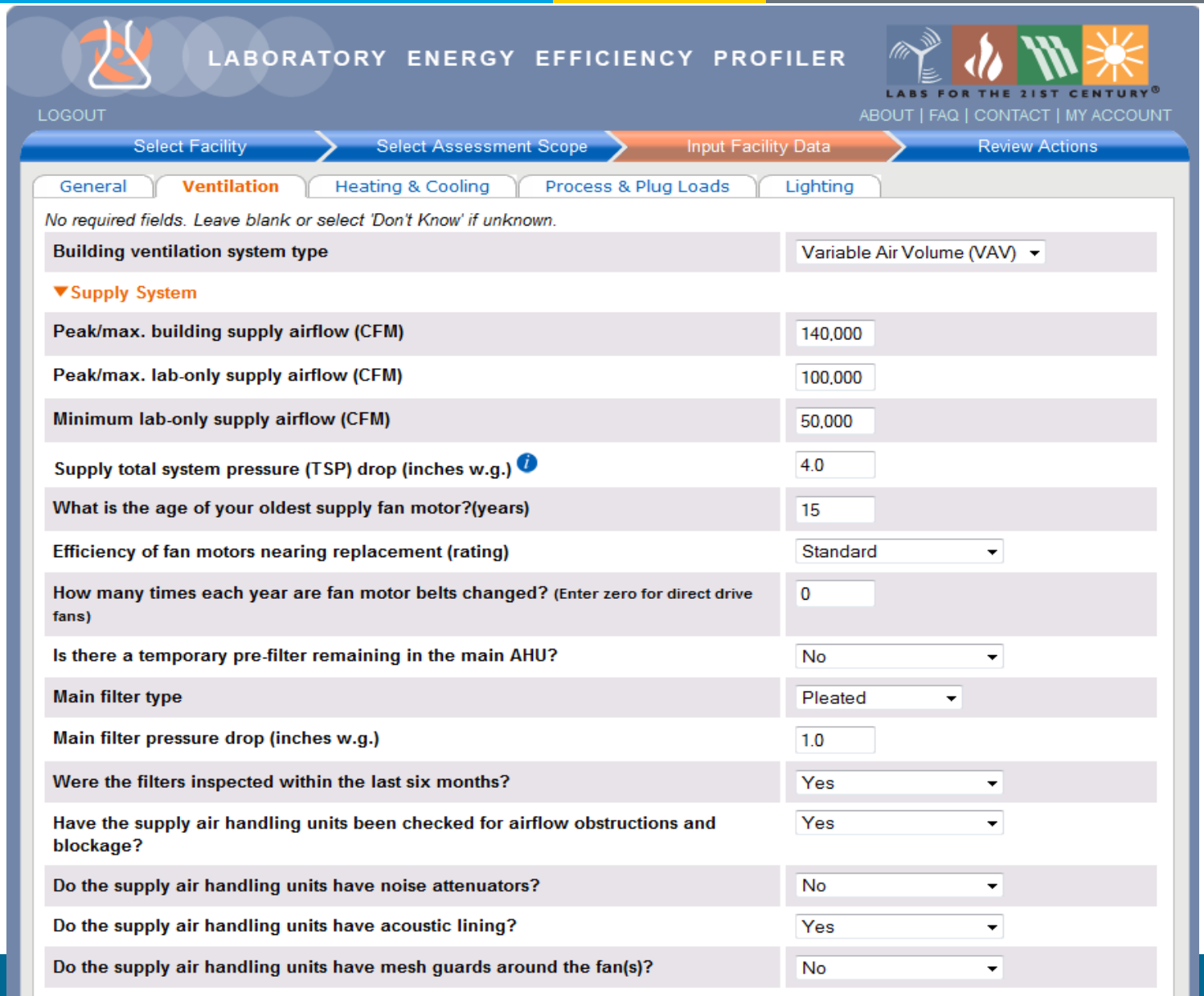

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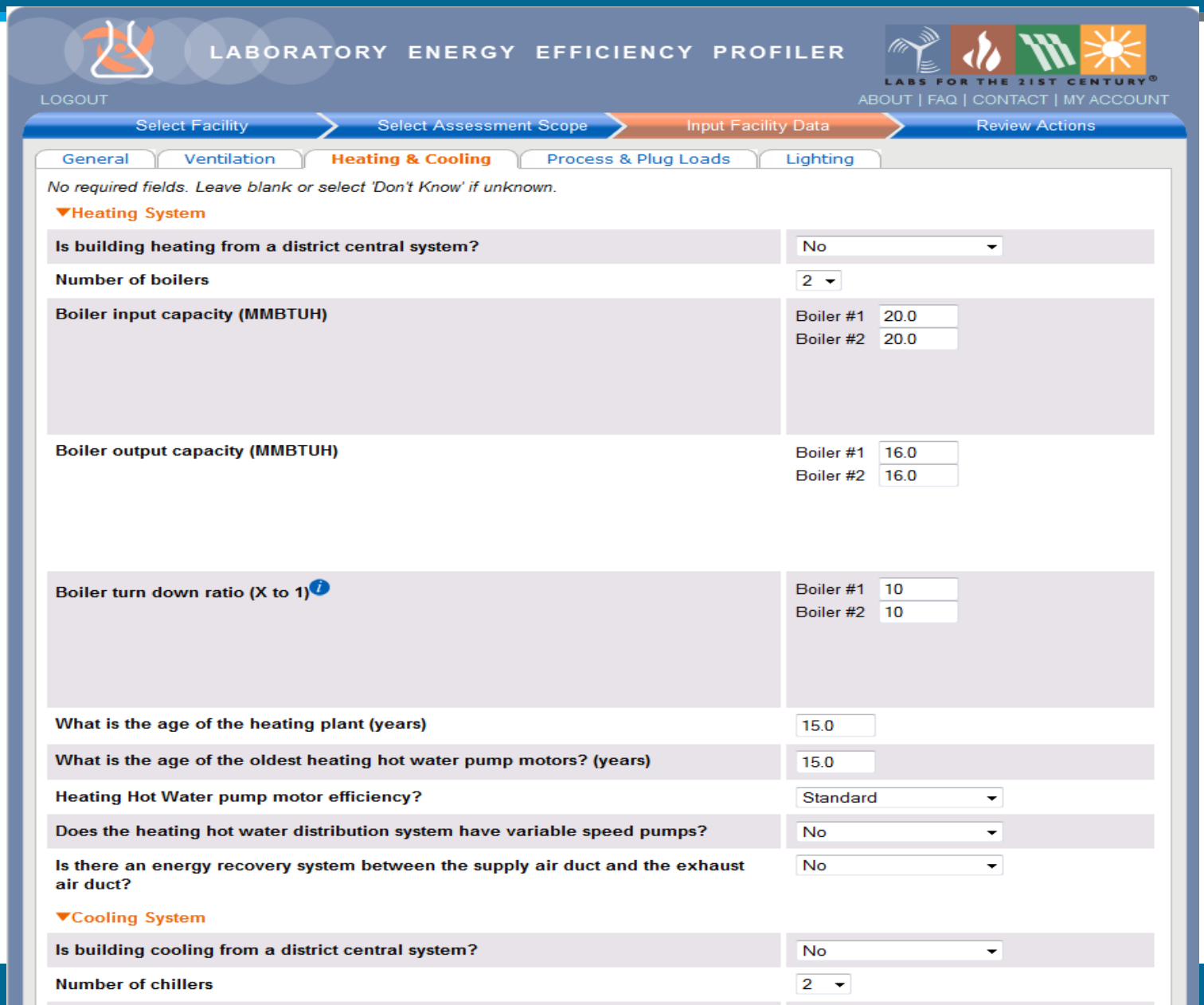

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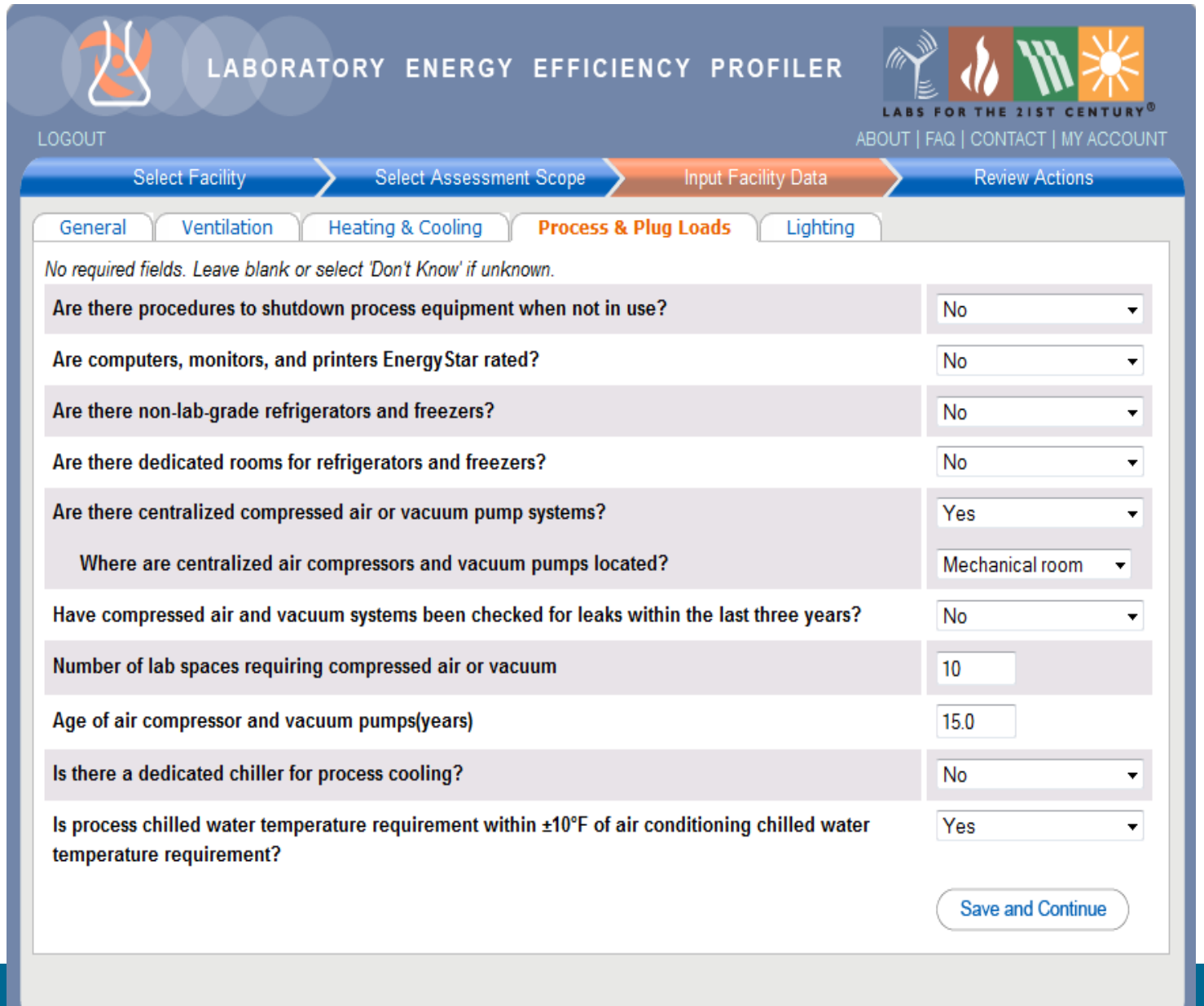

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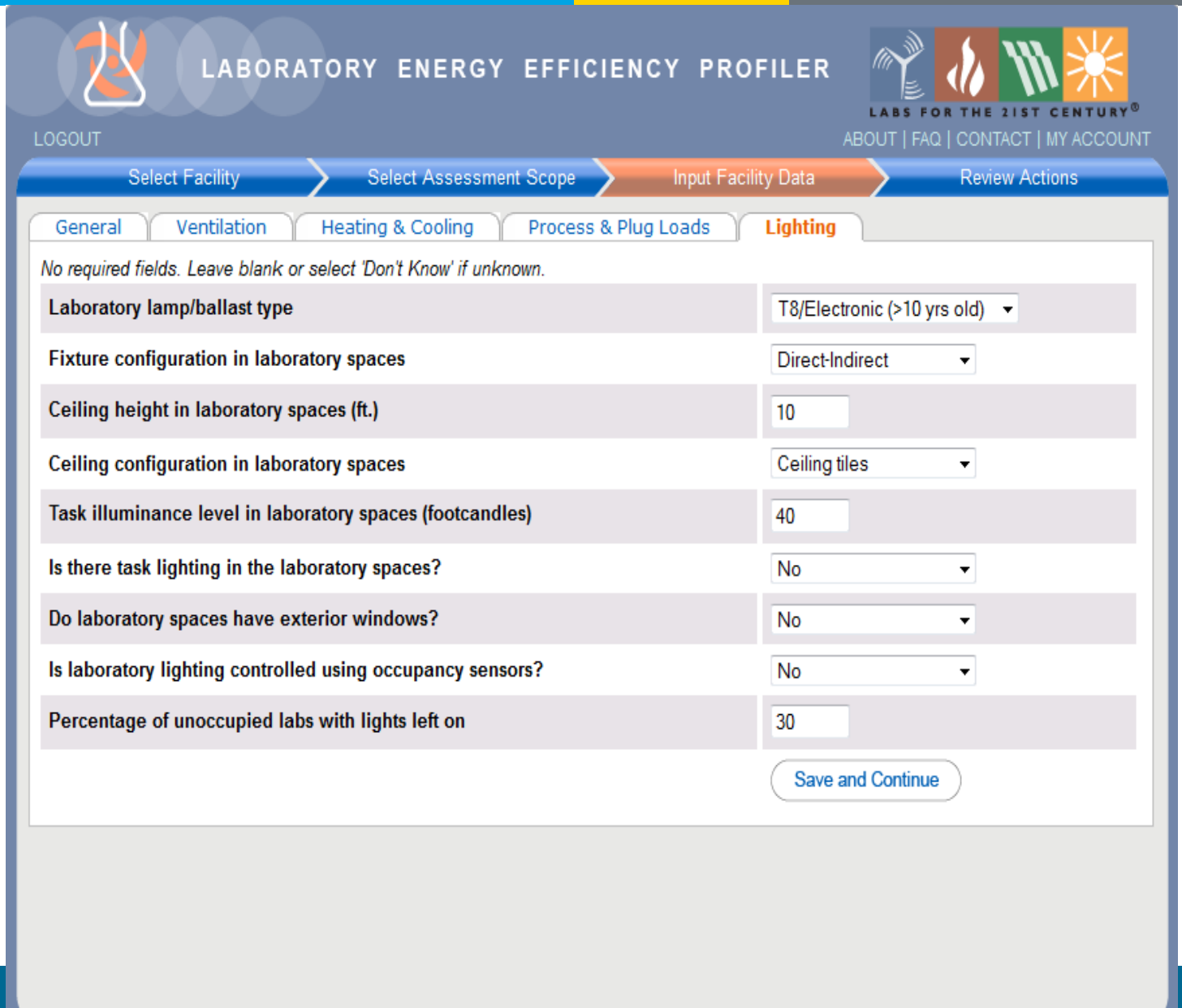

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Select Facility > Select Assessment Scope > Input Facility Data > Review Actions

Print Actions Report

High ● Likely ◐ Efficient ○

Big ● Medium ◐ Small ○

High $$$ Medium $$ Low $ Variable $-$$$

⊗ Not applicable

? Provide more information

Actions	Relevance	Impact	Cost	More Information
▼Ventilation				
Optimize (reduce) lab exhaust ventilation rate to minimum.	●	●	$-$$$	**Notes**: Results based on minimum exhaust ventilation rate greater than 1.2 CFM/sq ft of net lab area **Caution**: Ability to reduce exhaust rate dependent on number of lab exhaust devices +Conversion from CV to VAV expensive **Next Steps**: Review lab exhaust system and device types for adjustment potential *Less ▲*
Optimize (reduce) exhaust ventilation rate to minimum during unoccupied periods	●	●	$	**Notes**: Uses occupancy of less than 160 hours **Caution**: Ability to setback ventilation limited by AHJ + Ensure all stakeholders are included in setback scheme **Next steps**: Review action with AHJ for appropriateness + Monitor building operations to verify occupancy periods *Less ▲*
Optimize (reduce) supply ventilation rate.	○	⊗	⊗	
Optimize (reduce) number or size of hoods i.e. decomission some hoods.	◐	◐	$$$	**Notes**: Are all lab exhaust devices used? **Caution**: Ability to alter ventilation devices limited by AHJ + Involve all stakeholders to determine alternatives **Next steps**: Review action with AHJ for appropriateness + Inventory lab device requirements + Decommission unused/misused devices *Less ▲*
Install direct digital control (DDC) system.	○	⊗	⊗	
Install variable volume fume hoods.	○	⊗	⊗	
Install low-flow fume hoods.	⊗	⊗	⊗	
Improve fume hood sash management.	●	●	$-$$$	**Notes**: Results based more than 25% hoods open and unoccupied **Caution**: Ability to reduce exhaust rate dependent on number and type of lab exhaust devices + Implementing sash management has a wide range of costs from manual-by-user (lowest) to automatic (highest) **Next steps**: Inventory number, size & type lab hoods + Begin with regular user sash management training and

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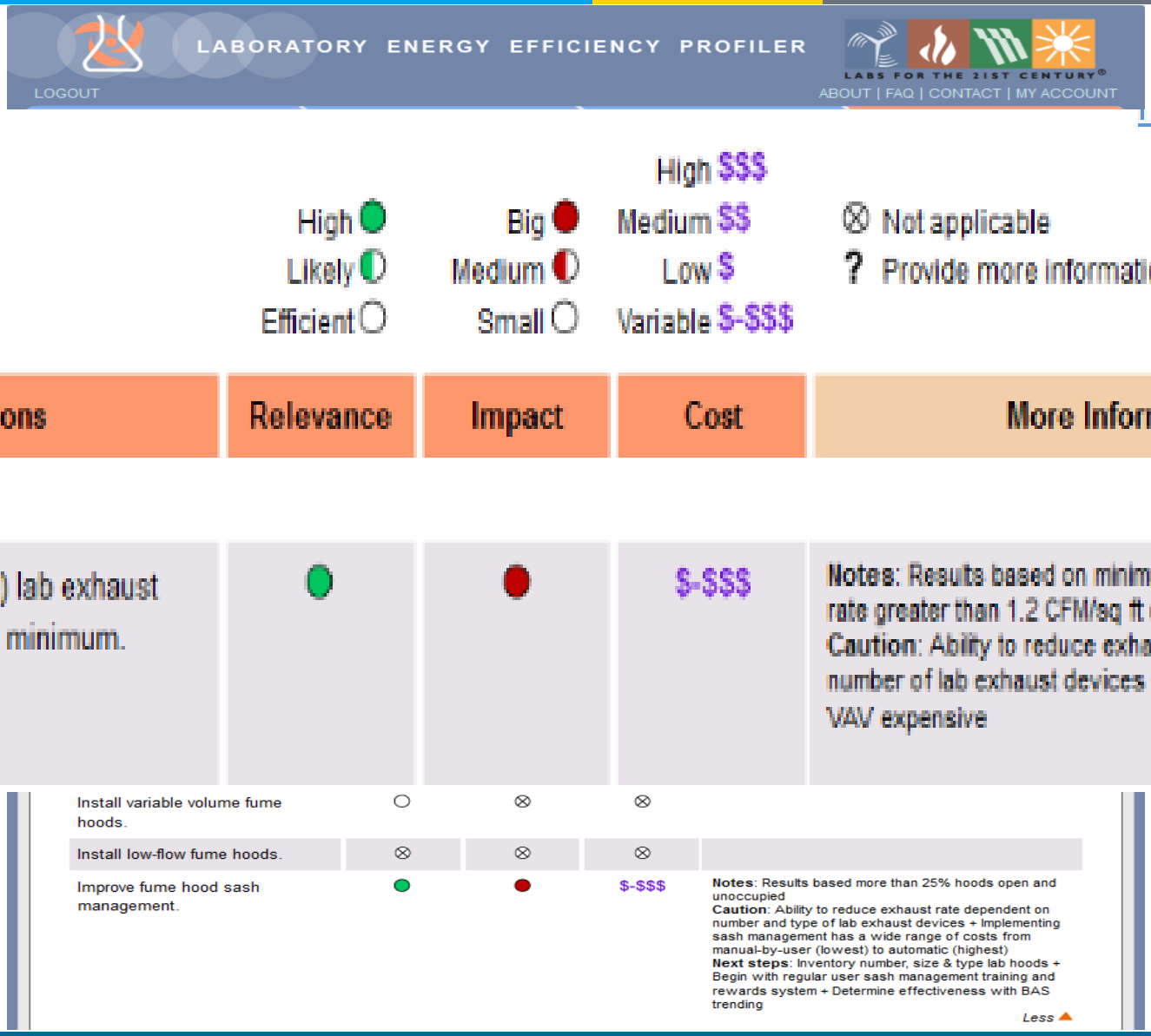

Monitoring and control system - Niagra

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Building 15

Fire Alarm Stair 1	Normal
Fire Alarm Stair 2	Normal

OA Temperature | Energy Dashboard | Gas Meters | BTU Meters | Water Meter

Laboratory Airhandling Units

	Manual Disable	Supply Temp	Intake (OA) Temp	Cooling Valve	Heating Valve	Fan Status	
AHU1	Normal	55.3 °F	76.1 °F	100.0 %	0.0 %	Running	Zones
AHU2	Normal	54.5 °F	76.1 °F	43.2 %	0.0 %	Running	Zones
AHU3	Normal	56.2 °F	76.1 °F	100.0 %	0.0 %	Running	Zones
AHU4	Normal	56.9 °F	76.1 °F	100.0 %	0.0 %	Running	Zones
AHU5	Normal	54.9 °F	76.1 °F	25.6 %	0.0 %	Running	Zones
AHU6	Normal	54.2 °F	76.1 °F	39.9 %	0.0 %	Running	Zones

Library Airhandling Unit ⇨

	Occupied Command	Supply Temp	Mixed Air Temp	Cooling Valve	Heating Valve	Fan Status	
AHU7	true	56.7 °F	75.7 °F	54.9 %	0.0 %	Running	Zones

Boiler ⇨

Boiler 1 Cmd	Enabled
Boiler 2 Cmd	Disabled
HWP 1 Status	Running
HWP 2 Status	Stopped
Boiler 1 Temp	176.0 °F
Boiler 2 Temp	132.7 °F

Chiller and Cooling Tower ⇨

Chiller 1 Cmd	Enabled	CT1A Fan	Running
Chiller 2 Cmd	Disabled	CT1B Fan	Running
CHWP 1 Status	Stopped	CWP 1 Status	Running
CHWP 2 Status	Running	CWP 2 Status	Stopped
CHWP 3 Status	Stopped	CWP 3 Status	Stopped
Water Temp	49.0 °F	Water Temp	66.2 °F

Exhaust Fans ⇨

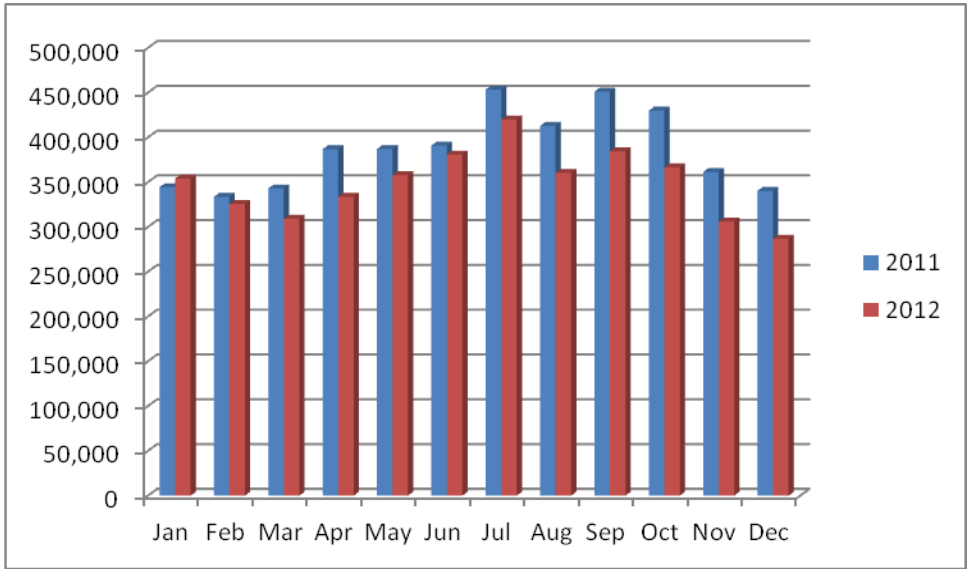
AHU1_2 System		AHU3_4 System		AHU5_6 System	
EF 1	Running	EF 5	Running	EF 9	Running
EF 2	Running	EF 6	Running	EF 10	Running
EF 3	Running	EF 7	Running	EF 11	Running
EF 4	Running	EF 8	Running	EF 12	Running

Miscellaneous Fans & EF-26 ⇨

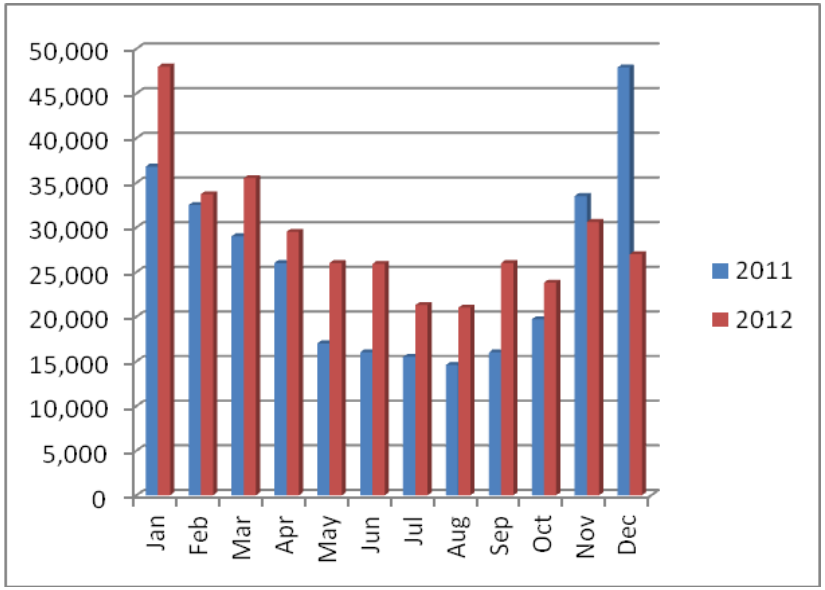
⇨ = hyperlink: Hotspot for jumping to associated equipment.

Power and gas use reduction 2011 to 2012

kWh



Therms



Monitoring and Control Equipment

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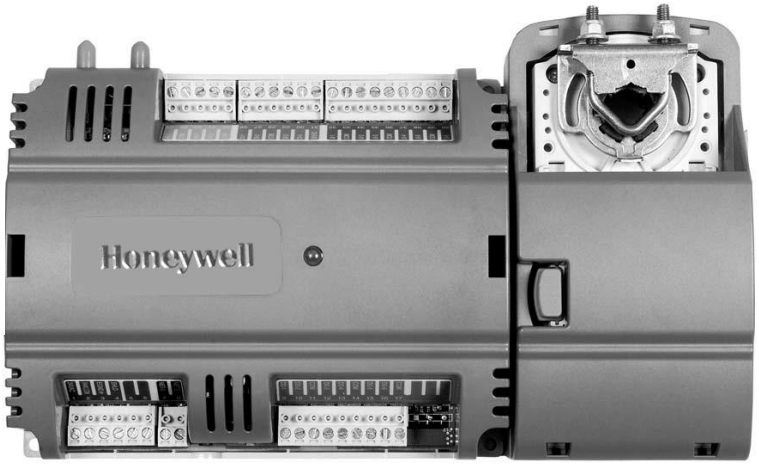
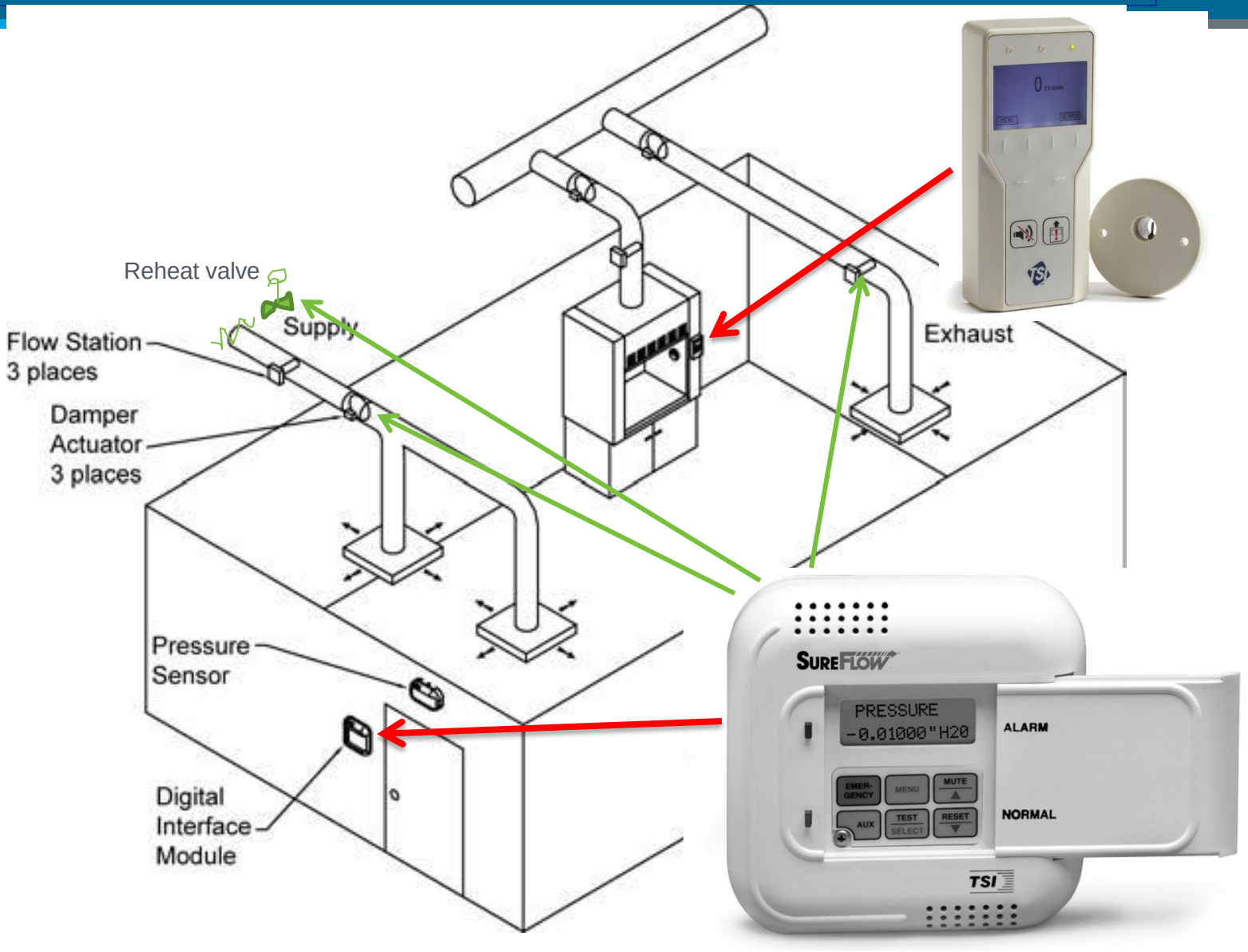


Courtesyy of TSI and Honeywell

B15 Typical Lab Control



VAV - Adaptive Control

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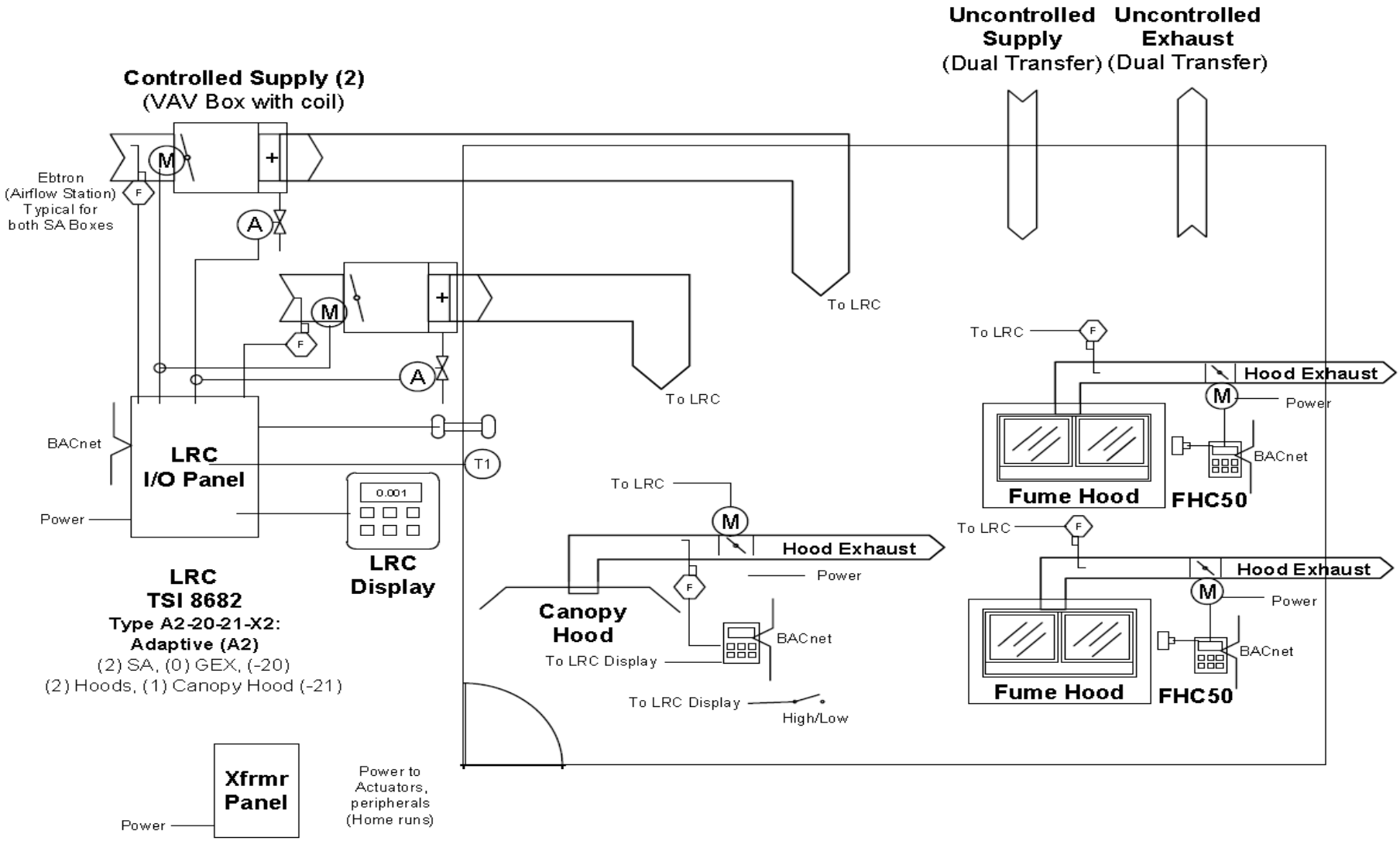

Courtesy of WAM

VFDs installed, opportunity?

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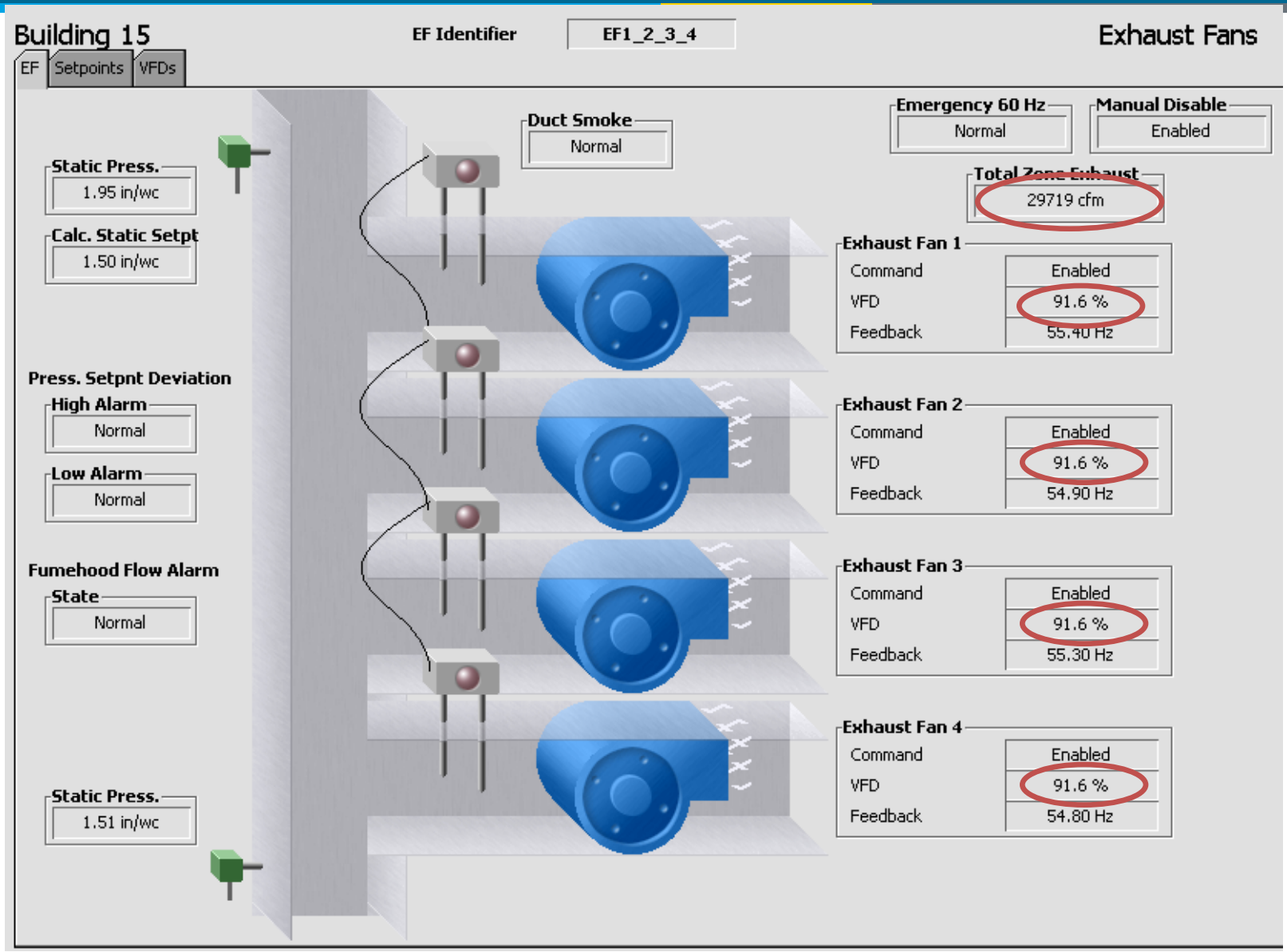

VFDs installed, opportunity?

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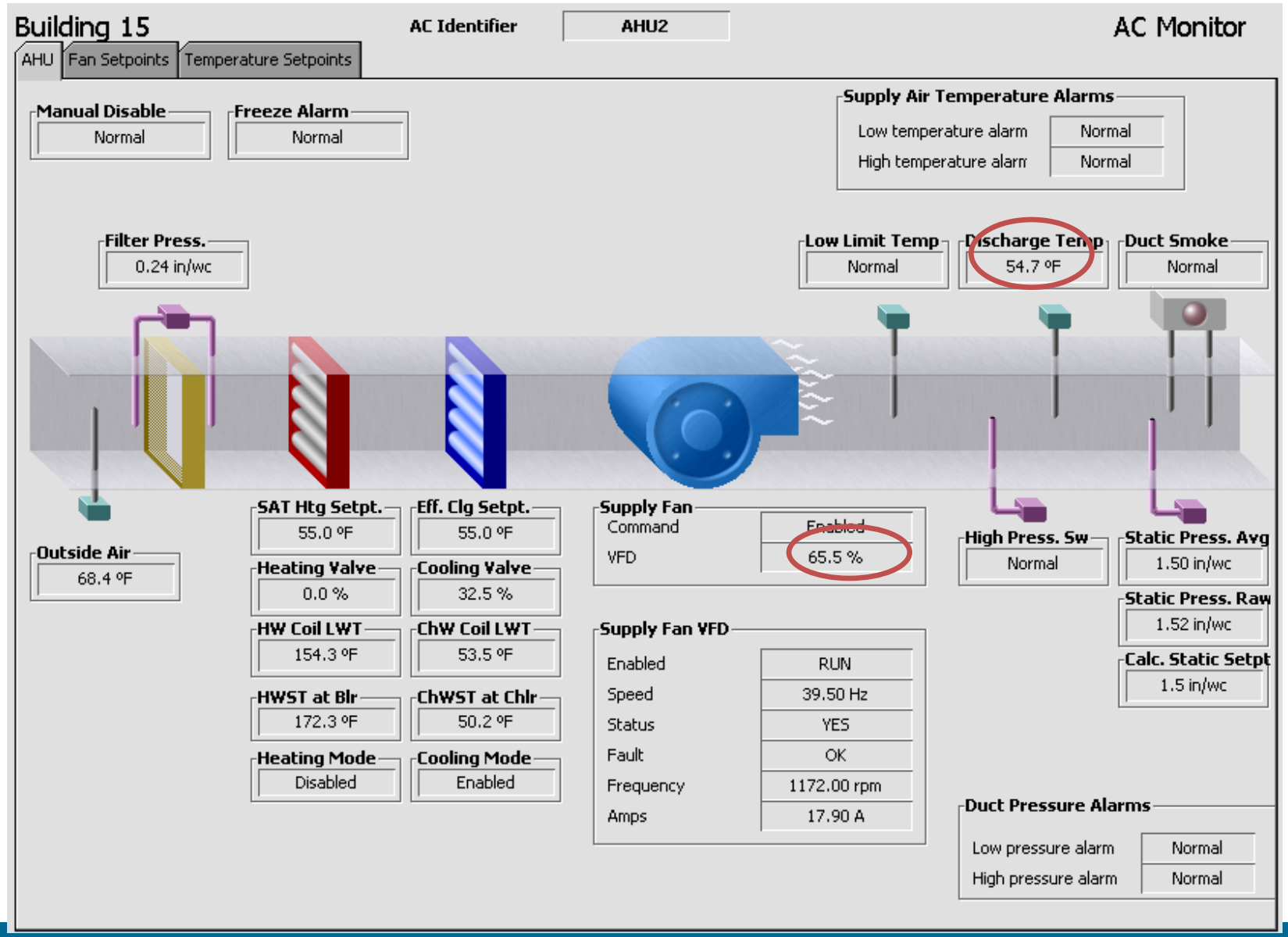

Reheat in all zones, almost

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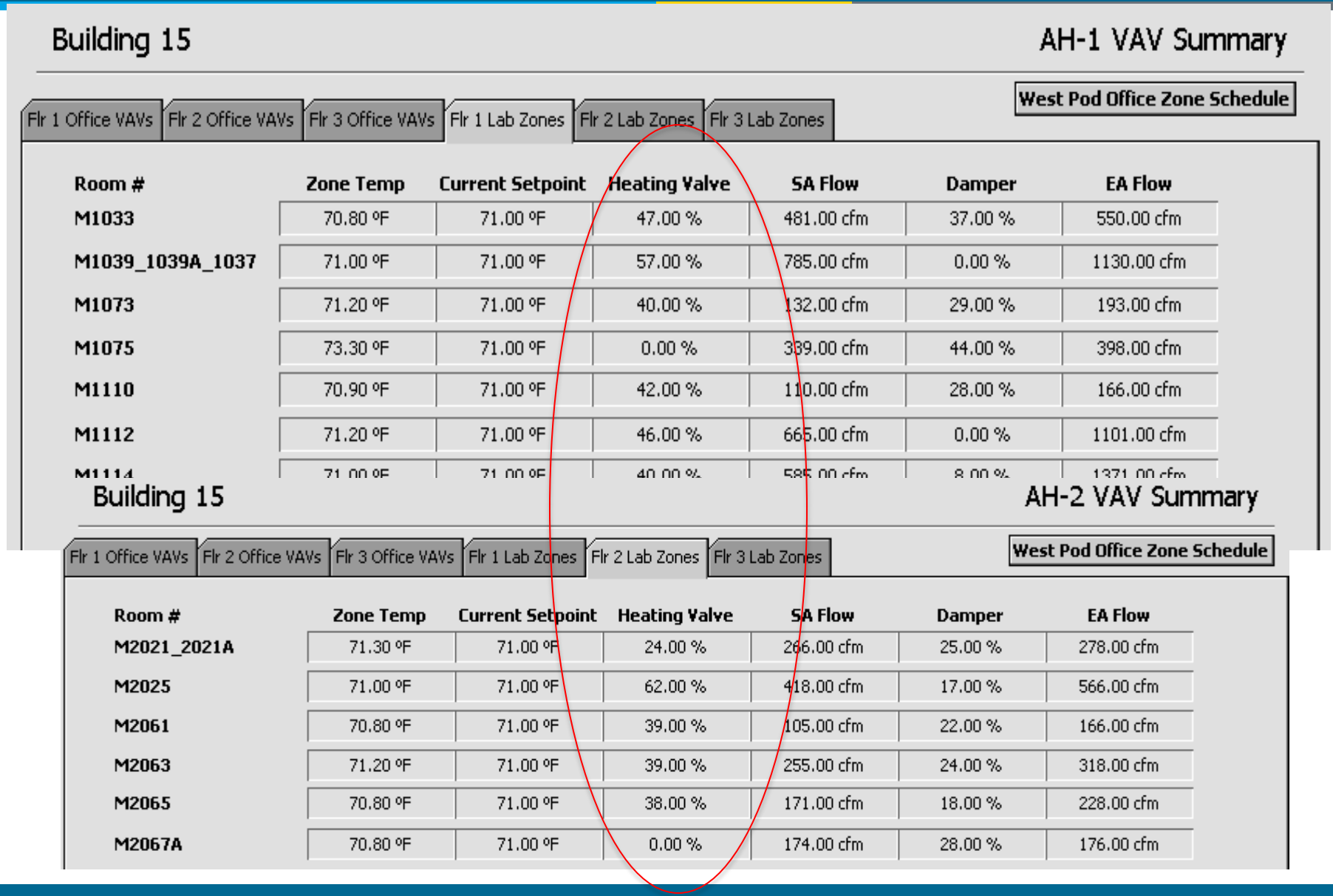


Building 15

AH-1 VAV Summary

West Pod Office Zone Schedule

Flr 1 Office VAVs | Flr 2 Office VAVs | Flr 3 Office VAVs | Flr 1 Lab Zones | Flr 2 Lab Zones | Flr 3 Lab Zones

Room #	Zone Temp	Current Setpoint	Heating Valve	SA Flow	Damper	EA Flow
M1033	70.80 °F	71.00 °F	47.00 %	481.00 cfm	37.00 %	550.00 cfm
M1039_1039A_1037	71.00 °F	71.00 °F	57.00 %	785.00 cfm	0.00 %	1130.00 cfm
M1073	71.20 °F	71.00 °F	40.00 %	132.00 cfm	29.00 %	193.00 cfm
M1075	73.30 °F	71.00 °F	0.00 %	339.00 cfm	44.00 %	398.00 cfm
M1110	70.90 °F	71.00 °F	42.00 %	110.00 cfm	28.00 %	166.00 cfm
M1112	71.20 °F	71.00 °F	46.00 %	665.00 cfm	0.00 %	1101.00 cfm
M1114	71.00 °F	71.00 °F	40.00 %	585.00 cfm	8.00 %	1371.00 cfm

Building 15

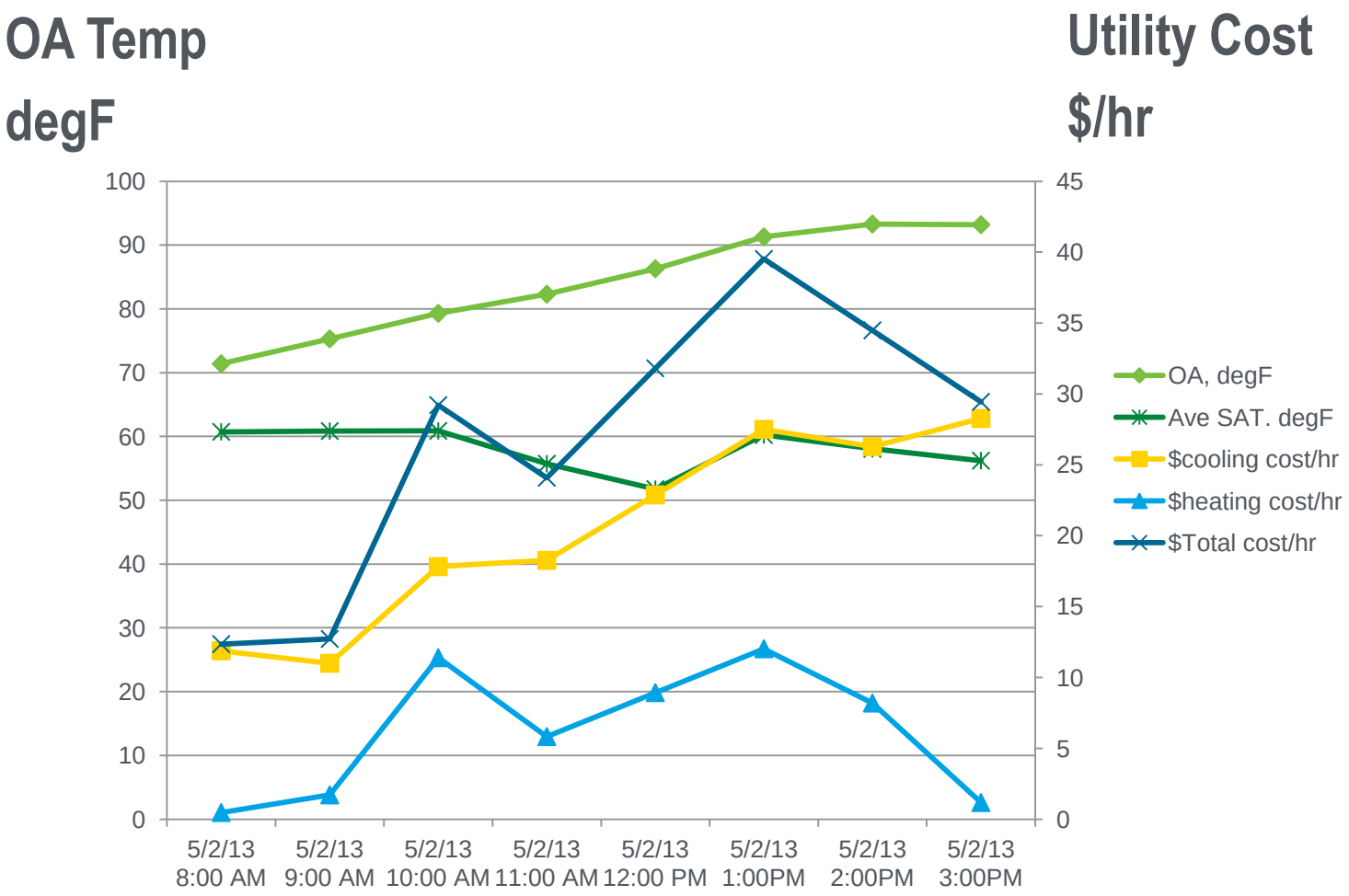
AH-2 VAV Summary

West Pod Office Zone Schedule

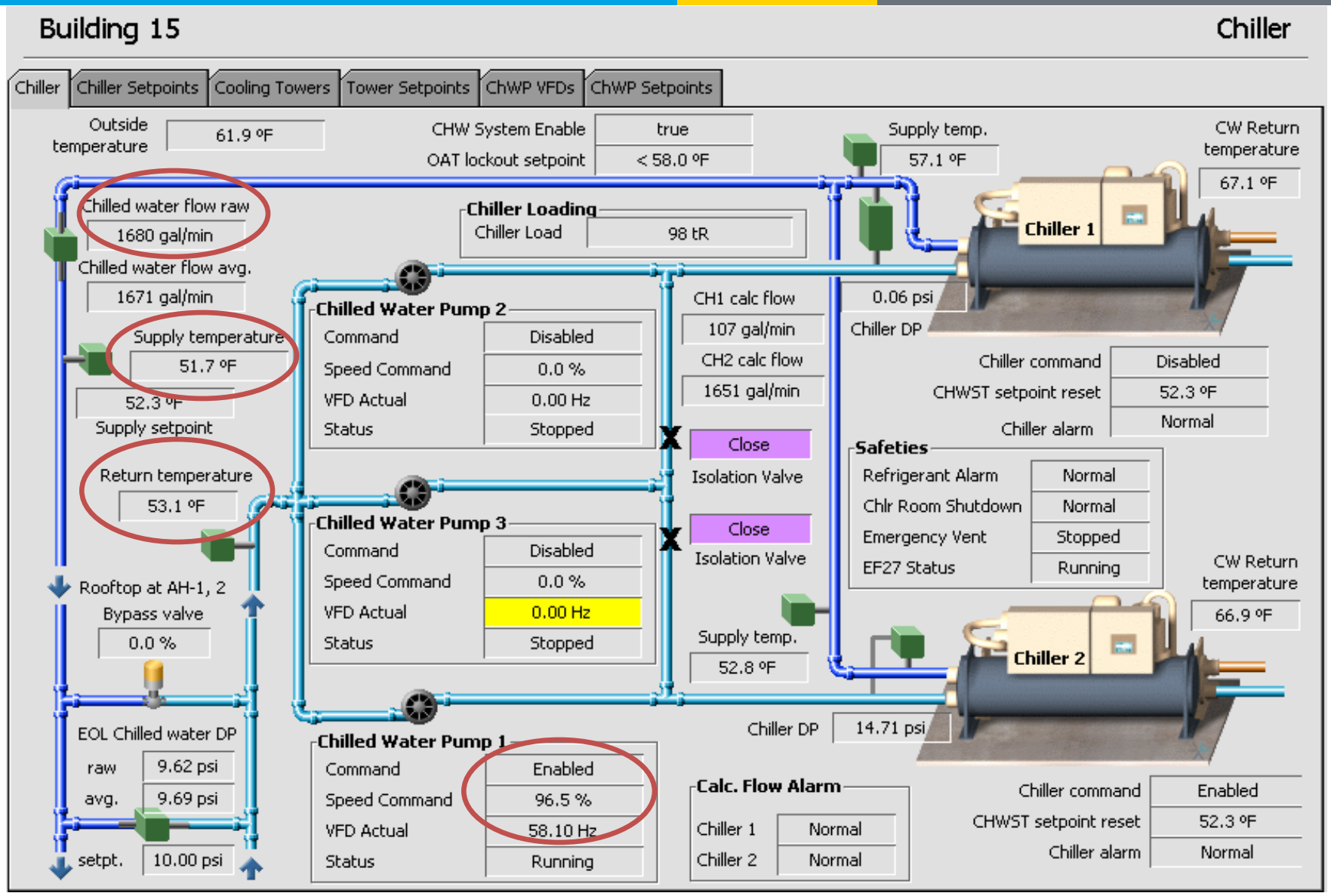
Flr 1 Office VAVs | Flr 2 Office VAVs | Flr 3 Office VAVs | Flr 1 Lab Zones | Flr 2 Lab Zones | Flr 3 Lab Zones

Room #	Zone Temp	Current Setpoint	Heating Valve	SA Flow	Damper	EA Flow
M2021_2021A	71.30 °F	71.00 °F	24.00 %	266.00 cfm	25.00 %	278.00 cfm
M2025	71.00 °F	71.00 °F	62.00 %	418.00 cfm	17.00 %	566.00 cfm
M2061	70.80 °F	71.00 °F	39.00 %	105.00 cfm	22.00 %	166.00 cfm
M2063	71.20 °F	71.00 °F	39.00 %	255.00 cfm	24.00 %	318.00 cfm
M2065	70.80 °F	71.00 °F	38.00 %	171.00 cfm	18.00 %	228.00 cfm
M2067A	70.80 °F	71.00 °F	0.00 %	174.00 cfm	28.00 %	176.00 cfm

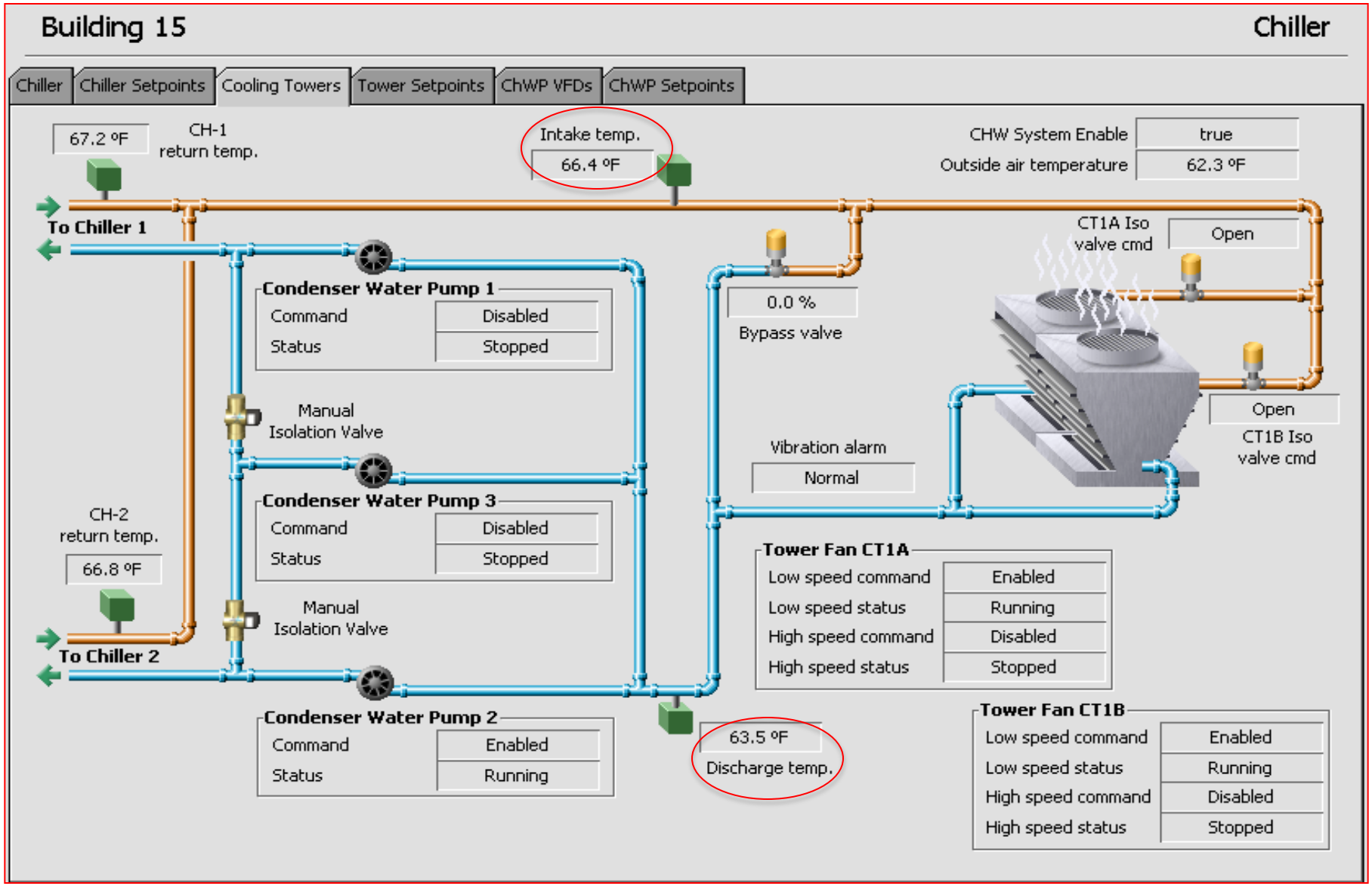
Cost of reheat



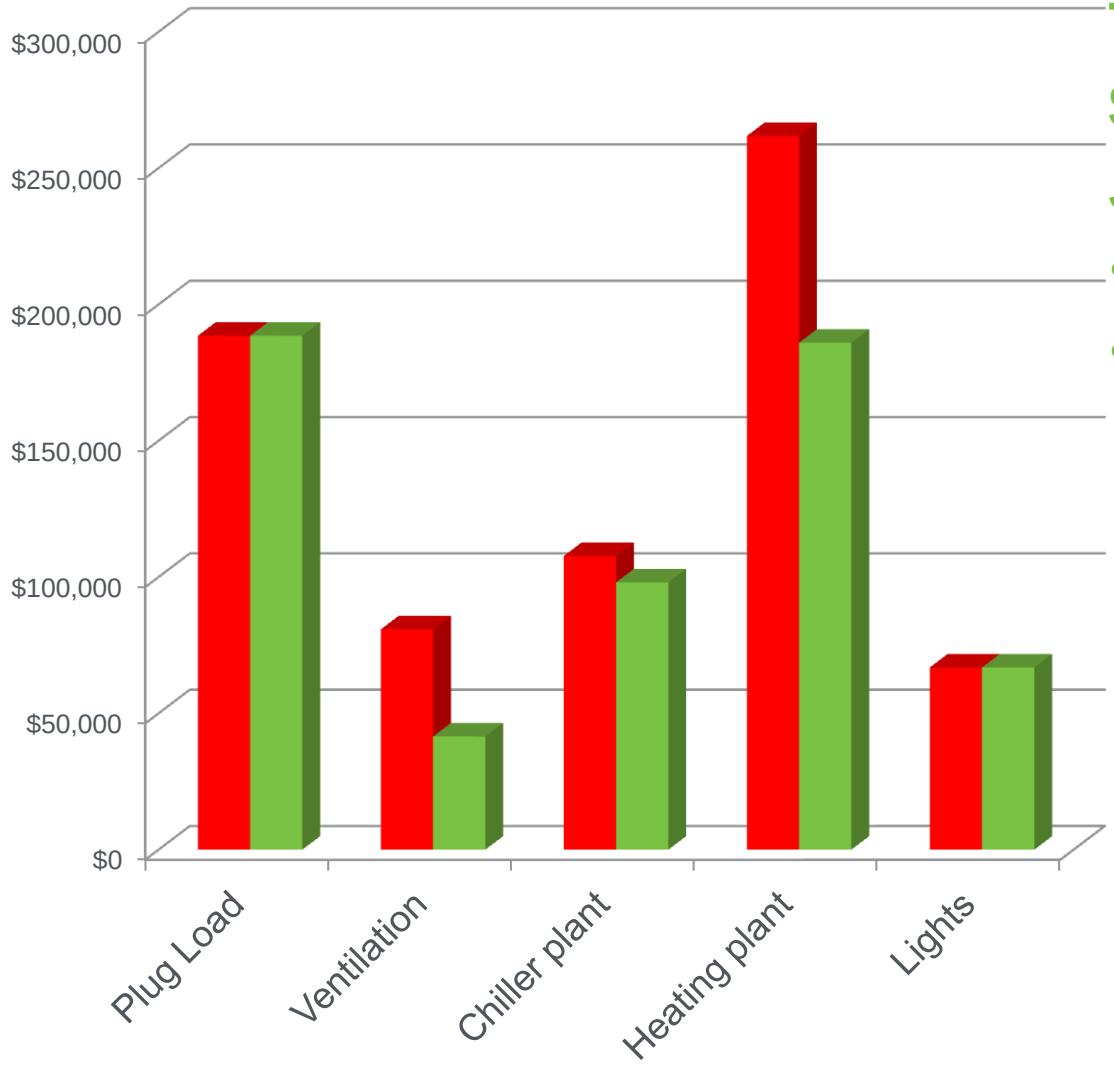
Monitoring few others…



..and few more…


Building 15
Chiller
Chiller
Chiller Setpoints
Cooling Towers
Tower Setpoints
ChWP VFDs
ChWP Setpoints
67.2 °F
CH-1 return temp.
Intake temp.
66.4 °F
CHW System Enable
true
Outside air temperature
62.3 °F
To Chiller 1
CT1A Iso valve cmd
Open
Condenser Water Pump 1
Command
Disabled
Status
Stopped
0.0 %
Bypass valve
Manual Isolation Valve
Open
CT1B Iso valve cmd
Vibration alarm
Normal
Condenser Water Pump 3
Command
Disabled
Status
Stopped
CH-2 return temp.
66.8 °F
Tower Fan CT1A
Low speed command
Enabled
Low speed status
Running
High speed command
Disabled
High speed status
Stopped
Manual Isolation Valve
To Chiller 2
Condenser Water Pump 2
Command
Enabled
Status
Running
63.5 °F
Discharge temp.
Tower Fan CT1B
Low speed command
Enabled
Low speed status
Running
High speed command
Disabled
High speed status
Stopped

Current and potential utility cost



Total saving of $110,000-$180,000 Just by:

- **Optimize Ventilation**
- **Minimize Reheat**

Questions?

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510.495.2259